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**RESPONSE UNDER 37 CFR 1.116  
EXPEDITED PROCEDURE**

**UNITED STATES PATENT AND TRADEMARK OFFICE**

**Board of Patent Appeals and Interferences**

**Checks Cashed, *pro se* Appeal Briefs Withheld**

**Case Numbers Redacted by Dr. Ricardo Palabrica *et alia***

**IN RE THE APPLICATION OF:**

Inventor : Mitchell R. Swartz

Serial no. 09/ 750,765

Filed: 12/28/00

**For: METHOD AND APPARATUS  
TO CONTROL ISOTOPIC FUEL  
LOADED WITHIN A MATERIAL**

This is a continuation of Serial no. 07/ 760,970

Filed: 09/17/1991

**PAPER:**

Group Art Unit: 3641

Examiner: Mr. Palabrica, R.J.

October 17, 2011

**Commissioner of Patents and Trademarks**

Box 1450 Alexandria, VA 22313-1450

**PETITION TO THE COMMISSIONER  
PURSUANT TO 37 C.F.R. 1.181**

1. This Petition is made by the *pro se* Appellant pursuant to 37 C.F.R. 1.181 to the Commissioner of Patents, and is made to invoke his supervisory authority to correct a wrongful situation involving a Decision of 04/04/2007, signed by Donald Hajec, ruling on his own group [Exhibit "A"; hereinafter simply 'Decison'].

2. Pursuant to 37 C.F.R. 1.181, there is no fee. This Petition is reasonable based upon the reasons stated below, and the facts as discussed in the Declarations supporting this Petition.

3. In the discussion below, reference is made to the Declaration of Dr. Mitchell Swartz (hereinafter called the "Swartz Declaration") dated October 17, 2011. In addition, attention is directed to the previous Swartz Declarations dated May 5, 2003, April 21, 2004, May 26, 2004, April 10, 2006, May 25 2006. Attention is also directed to the previous Verner Declarations dated April 21, 2004, and several Declarations submitted on October 23, 2002.

## BACKGROUND

4. Serial no. 09/750,765 is a continuation of Serial no. 07/ 760,970. It involves a two-stage process involving loading of hydrogen into a metal electrode such as palladium. Applicant taught using a first stage of electrode loading, followed by, a second stage of sudden rapid ("catastrophic") flow of the loaded hydrogen within the metal. Applicant taught in the original specification and claims how this apparatus works and presented objective detailed evidence of the invention. The first stage is the electrode loading, and then, in the second stage a rapid ("catastrophic") flow of hydrogen results within the metal. After the initial loading, said flow (or flux) of hydrogen takes place until the previously-loaded palladium is spent of its deuterons or the material is otherwise damaged.

5. The Applicant appealed the Examiner. The *pro se* Appellant filed Appeal Briefs. The first *pro se* Appeal Brief was filed on October 24, 2003 ( tk pages). Under the unending demands of Dr. Ricardo Palabrica, the second, revised *pro se* Appeal Brief was then refiled on January 4, 2004 (tk pages, again in triplicate with triplicate Exhibits) All have since been sequestered, removed, "lost" or destroyed by Dr. Ricardo Palabrica et alia.

**6. There were no deficiencies as the Office purports. The Appellant made every attempt to comply with 37 CFR 1.192(c) in an organized manner for judicial economy and to maximize clarity for the Board.**

7. MPEP 1206 states:

**"An exception to the requirement that all the itemsspecified in 37 CFR 1.192(c) be included in the brief is made if the application or reexamination proceeding is being prosecuted by the appellant *pro se*".**

8. The Appellant addressed the Compliance and other relevant issues both in the Swartz Declarations and in the other, too long-ignored responses and communications to the USPTO. For example, the Appellant addressed these issues in his (sequestered, "lost" or destroyed) missives entitled, Notice of Compliance [January 4, 2004], Motion for Sanctions [April 21, 2004], and Responses to the USPTO [April 21, 2004 and May 26, 2004].

9. The *pro se* Appellant has also filed an unaddressed Motion for Sanctions supported by un rebutted Declarations. The Examiner Dr. Ricardo Palabrica has systematically ignored timely submitted responses. In addition, he has systematically ignored timely submitted Declarations and other Exhibits (some of which on information and belief have been "missing" from the file folder).

10. The response of the Office to the *pro se* compliant Appeal Briefs involving energy production has been the following:

The Office has ignored the *pro se* Appellant's Appeal Briefs.

The Office has ignored the *pro se* Appellant's Responses.

11. The *pro se* Appellant has also filed several substantively ignored Petitions to the Commissioner supported by un rebutted Declarations. The issues involve matters of impropriety which have not even been addressed. Specifically, the Office has ignored the issues in Appellant's Petitions filed on April 26, 2004 and May 28, 2004.

12. The response of the Office to the Petitions has been the following:

The Office has ignored documented complaints by the *pro se* Appellant.

The Office has ignored the *pro se* Appellant's Petitions to the Commissioner.

13. The Decision of 04/04/2007, signed by Donald Hajec, ruling on his own group, states that the Petition is "DISMISSED as MOOT" [hereinafter "Dismissed"]. As the Swartz Declaration states,

**"The Petition is "DISMISSED as MOOT" but the Decision has not even substantively addressed the serious issues of said Petition. The Decision is egregious because the issues in the Petition which have been ignored involve the Office failing to respond to arguments, failing to respond to Declarants, and other matters of impropriety. Furthermore, the Decision is itself an impropriety since it is signed by Donald Hajec ruling on his own group's questionable conduct."**

14. The Decision has the appearance of impropriety. The Decision is not accurate and is unfair.

15. The Decision has the appearance of impropriety. The Decision does not address the issues of said Petitions.

16. The Decision has the appearance of impropriety. The Petitioner requested to know the substantive precise reason, scientific basis, or authority which allowed the Office to dismiss the Arguments by the Applicant without citation, analysis, or substantive coherent response. That issue, like the other issues, were simply ignored.

17. The Decision has the appearance of impropriety. Mr. Hajec, ruling on his own group, did not cite Petitioner's arguments, discuss Petitioner's arguments, or rebut Petitioner's arguments. Therefore it is impossible to tell how the Office weighed Petitioner's arguments. There was absolutely no way for the Petitioner to present the Office's reasons for rejection to the Board of Appeals or the federal or state courts in the Commonwealth of Massachusetts.

### **APPEAL BRIEF SEQUESTRATION IS SERIOUS AND IMPORTANT**

18. Attention is directed to Exhibits "B" and "C" of which Examiner Palabrica was notified by Declaration. These are serious matters. Dr. Palabrica has said there was "no utility" when the DIA and DTRA and NRL had said otherwise of the Applicant of the above-entitled Application, and the subject matter of the above entitled Application. As the Swartz Declaration states,

**"I previously informed Examiner Palabrica of the relevant matters such as described in Exhibits "B" and "C". In return, he has been disingenuous on federal documents and with the Board of Patent Appeal, purporting that there is "no utility" to the above-entitled invention even when documents associated with the DIA, DTRA, NRL, and other agencies have indicated the opposite."**

19. The Decision has the appearance of impropriety. The sequestered *pro se* Appeal Brief is relevant to the Board of Patent Appeals. It is not only a travesty that it has been withheld, but it is also relevant to other cases presently before the Board which directly affect and are directly affected by or have a bearing on the Board's decision in the pending appeal.

20. The Decision has the appearance of impropriety. The reason the Appeal Briefs have been withheld by the Examiner(s) who are exposed having also removed Evidence from those file folders in cases which were before the Board of Patent Appeals (*vide infra*).

21. The Decision has the appearance of violations of MGL 93A. The Office has for years continued to cash the Applicant's checks for patent applications and then Appellant's (then Applicant's) checks for Appeals before the Board of Patent Appeals which has been denied to the *pro se* Applicant by disingenuous statements.

22. The Decision has the appearance of obstruction of justice and systematic abuse. The Examiner Dr. Ricardo Palabrica has systematically attempted to throw out each of Applicant's (now Appellant's) applications, including the above-entitled application, using false statements, false abandonments.

23. Since the Appeal Brief was filed, there has been a systematic delay to send this to the Board for years. This has the appearance of impropriety and may be perceived as an obstruction of justice and egregious lack of ethics.

### LAW

24. The *pro se* Appellant has been compliant, timely, and complete. The present Decision, as it stands, has both the salient appearance of impropriety and obstruction of justice.

25. The Office has ignored several laws and its own rules, including but not limited to:

26. There have been violations by the Office of MPEP 1206.

27. There have been violations by the Office of 18 U.S.C. §1001.

28. There have been violations by the Office of the 5th Amendment and 14th Amendment; also "equal protection" clauses, and 42 U.S.C. §1983.

29. There have been violations by the Office of Title 18 U.S.C., Sections 1831 and 1832.

30. The Office has ignored U.S. Rep volume 404, pages 520-521 (72).

COUNT #1 - Violation of 18 U.S.C. §1001

COUNT #2 - Regulatory Abuse

COUNT #3 - Obstruction of Justice

COUNT #4 - Misprision of Felony by Robert W. Bahr

COUNT #5 - Misprision of Felony by Donald T. Hajec

COUNT #6 - Misprision of Felony by Past Director Jon W. Dudas

COUNT #7 - Misprision of Felony by Director of Patents

31. Therefore, as discussed above, the Decision was in error and should be corrected. This Petition is an attempt by the Petitioner for judicial economy.

32. Appellant notes that the U.S. Supreme Court has ruled that any *pro se* litigant is entitled to less stringent standards [U.S. Rep volume 404, pages 520-521 (72)].

WHEREFORE, this Petition, supported by Affidavit and consistent with proven facts in the record, proves the Appellant correct. Applicant (now Appellant) respectfully requests

i) relief from the Examiner's false statements made on federal documents sent through the US mail to obstruct justice, precisely that the above-entitled application file was NOT abandoned, and

ii) a recusal of the Examiner Ricardo Palabrica from all of Applicant's cases, and

iii) properly transferring the Dr.Palabrica-sequestered Appeal Brief to the Board of Patent Appeals immediately consistent with the checks which were cashed and compliant *pro se* Appeal Briefs were delivered.

Respectfully submitted,



Mitchell Swartz, ScD, MD, EE

### **CERTIFICATE OF MAILING [37 CFR 1.8(a)]**

October 17, 2011

To Whom it Does Concern:

I hereby certify that this correspondence will be deposited with the United States Postal Service by First Class Mail, postage prepaid, in an envelope addressed to  
"The Commissioner of Patents and Trademarks  
Washington, D.C. 20231" on the date below.

Thank you.

Sincerely,

October 17, 2011



M.R. Swartz



# UNITED STATES PATENT AND TRADEMARK OFFICE

## Board of Patent Appeals and Interferences

Checks Cashed, *pro se* Appeal Briefs Withheld

Case Numbers Redacted by Dr. Ricardo Palabrica *et alia*

IN RE THE APPLICATION OF:

PAPER:

Inventor : Mitchell R. Swartz

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Group Art Unit: 3641

Examiner: Mr. Palabrica, R.J.

October 17, 2011

**Commissioner of Patents and Trademarks**

Box 1450 Alexandria, VA 22313-1450

### DECLARATION OF DR. M. SWARTZ SUPPORTING PETITION to the COMMISSIONER

I, Mitchell R. Swartz, declare that I am a citizen of the United States of America and the inventor of the invention described in the above-entitled application.

1. I have a background in electrical engineering, material science, electrochemistry, nuclear physics, and medicine. I have worked in these fields for almost thirty years, and have worked on medical and scientific experimental projects at the Massachusetts Institute of Technology, Massachusetts General Hospital, Harvard Medical School, and elsewhere.

2. I have received an unfair and wrongful Decision [Exhibit "A"] dated 4/04/2007.

3. The Petition is "DISMISSED as MOOT" but the Decision has not even substantively addressed the serious issues of said Petition.

4. The Decision is egregious because the issues in the Petition which have been ignored involve the Office failing to respond to arguments, failing to respond to Declarants, and other matters of impropriety.

5. Furthermore, the Decision is itself an impropriety since it is signed by Donald Hajec ruling on his own group's questionable conduct.

6. I previously informed Examiner Palabrica of the relevant matters such as described in Exhibits "B" and "C". In return, he has been disingenuous on federal documents and with the Board of Patent Appeal, purporting that there is "no utility" to the above-entitled invention even when documents associated with the DIA, DTRA, NRL, and other agencies have indicated the opposite.

I declare that all statements herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signature of Inventor:

October 17, 2011



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Mitchell R. Swartz, ScD, MD, *pro se*  
Weston, Mass. 02481



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents  
United States Patent and Trademark Office  
P.O. Box 1450  
Alexandria, VA 22313-1450  
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FROM DIRECTORS OFFICE

APR 04 2007

TECHNOLOGY CENTER 3600



Mitchell R. Swartz ScD, MD, EE  
16 Pembroke Road  
Weston, MA 02493

In re Application of  
Mitchell R. Swartz  
Application No. 09/750,765  
Filed: December 28, 2000  
For: METHOD AND APPARATUS TO CONTROL  
ISOTOPIC FUEL LOADED WITHIN A  
MATERIAL

DECISION ON THE PETITION  
UNDER 37 CFR 1.181

Exhibit "A"

This is a decision on applicant's petitions filed on May 30, 2006 under 37 CFR 1.181, to the petition decision dated May 22, 2006 regarding the non-compliant Appeal Brief.

The petition is **DISMISSED as MOOT**.

**DISCUSSION**

It is noted that the application is currently in abandoned status. Applicant petitioned the holding of abandonment in the petition dated June 15, 2006 which is currently with the Office of Petitions. It appears that the issues addressed in this petition are included in the above noted petition and will be addressed along with the issue of abandonment. No decision has been rendered by the Office of Petitions as of the date of this decision.

Accordingly, the May 30, 2006 petition is moot as the application is in abandoned status. Petitions do not extend time periods and are not considered to be proper responses.

**ADDITIONAL DISCUSSION**

It is noted that applicant has filed numerous petitions regarding this application and other co-pending applications the petitioner is advised that the Office has, pursuant to 35 U.S.C. § 1, established a federal regulation (37 CFR 10.18) that governs, among other things, the conduct of parties appearing before the Office whether in person, or in writing. Federal regulations have the force of law. For petitioner's benefit, the statute and regulation read as follows, in pertinent part:

**35 U.S.C. 1 Establishment.**

(a) **ESTABLISHMENT.**— The United States Patent and Trademark Office is established as an agency of the United States, within the Department of Commerce.

...

(b) **SPECIFIC POWERS.**— The Office—

...

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# High Energy Science and Technology Assessment

## FINAL REPORT

June 29, 2007

Exhibit "B"

Prepared for:



**Defense Threat Reduction Agency  
Advanced Systems and Concepts Office**

**Contract No: DTRA01-03-D-0017**

**Task Order 18**

**Technical Instruction 18-06-11**

Prepared by:

**Rich Sutton, George Ullrich**

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**SPONSOR:** Defense Threat Reduction Agency  
Dr. James Tegnalia  
Director

Advanced Systems and Concepts Office  
Dr. Michael Wheeler  
Director

**BACKGROUND:** The Defense Threat Reduction Agency (DTRA) was founded in 1998 to integrate and focus the capabilities of the Department of Defense (DoD) that address the weapons of mass destruction threat. To assist the Agency in its primary mission, the Advanced Systems and Concepts Office (ASCO) develops and maintains an evolving analytical vision of necessary and sufficient capabilities to protect United States and Allied forces and citizens from WMD attack. ASCO is also charged by DoD, and by the U.S. Government generally, to identify gaps in these capabilities and initiate programs to fill them. It also provides support to the Threat Reduction Advisory Committee (TRAC), and its Panels, with timely, high quality research.

**ASCO ANALYTICAL SUPPORT:** Science Applications International Corporation has provided analytical support to DTRA since the latter's inception through a series of projects on chemical, biological, and nuclear weapons issues. This work was performed for DTRA under contract DTRA01-03-D-0017, Task Order 18.

**SUPERVISING PROJECT OFFICER:** Mr. David Algert., 703 767-5704

**SCIENCE APPLICATIONS INTERNATIONAL CORPORATION:** 1710 SAIC Drive, McLean, Virginia, 22102. Telephone: (703) 676-5550. Project Coordinator: Dr. George Ullrich, Senior Vice President for Advanced Technology Programs, (703) 676-8752.

**REPORT:** The publication of this document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of the sponsoring agency.

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## **1.0 Executive Summary**

The potential energy that can be tapped from the nucleus ( $> 10^6$  eV/atom) is vastly greater than the energy available from the electronic states of an atom ( $< 1$  eV/atom). The conversion of mass into energy, via fission and fusion reactions, is the basis for the only existing "high-energy" weapons, but further refinements in the design of these weapons, to make them more relevant to the post-Cold War security environment, are certainly possible. Another possible way to extract energy from the nucleus is to exploit the energy stored in metastable isomeric states. Also, despite the negative publicity about "Cold Fusion," the nuclear community continues to watch research in the area of low energy nuclear reactions with guarded optimism for possible future commercial and military applications. Anti-matter annihilation reactions involve the complete conversion of mass to energy with energy densities three orders of magnitude higher than nuclear fission and fusion. The prospect of compactly storing positrons in the form of charge-neutral positronium holds promise for viable military applications of anti-matter.

The Defense Threat Reduction Agency (DTRA) is chartered to monitor new potentially militarily useful sources of energy and to maintain cognizance of others' work in these fields as a hedge against technology surprise.

DTRA tasked SAIC under Contract DTRA01-03-D-0017, Technical Instruction 18-06-11, to conduct a Workshop on a wide range of energy-related technologies that are not chemical in nature, but have credible scientific basis and preliminary experimental results.

The format for the Workshop included a Panel of invited Subject Matter Experts (collectively referred to as the Expert Panel) well versed in the candidate technologies with a broad experience base in past DoD/DTRA advanced technology programs. This Panel was charged with providing individual critiques regarding the status and potential of four primary high energy technology research areas. The Expert Panel consisted of the Honorable Harold Smith, former DoD/ATSD(NCB) and currently a Distinguished Visiting Scholar and Professor at UC, Berkeley; Dr. Jack Davis, ST Executive, Plasma Physics Division, NRL; Dr. Gerald Yonas, Director, Advanced Concepts Office, Sandia National Laboratory; and Dr. Fred Wikner, former OSD Director of Net Assessment and presently consultant to Applied Research Associates Inc.

To avoid a myriad of disparate perspectives on each of the topic areas, a key expert was assigned to coordinate the presentations in each topic area and to serve as the Chairman of the topic area Panel. The four topic areas and the respective Panel Chairs were:

**Low Energy Nuclear Reactions (LENR),** Dr. David Nagel, GWU

**Anti-Matter Annihilation,** (b)(6)

**Nuclear Isomers,** Dr. Jim Silk, IDA

**Advanced Nuclear Fission and Fusion Concepts, Dr. Don Linger, DTRA**

An additional topic that was discussed but which did not have a Panel was, **Exotic/Extreme Physics.**

Each of the panels presented impressive results showing good progress in experimental design and execution and in first-principal demonstration of energy extraction, containment and control. Unfortunately, none of the energy sources studied are yet sufficiently advanced to be considered for development in the next five to seven years.

The Expert Panel noted the embryonic stage of development of most of the high energy technologies, and commented that DTRA, as a combat support organization, should stay abreast of the work but not necessarily serve as the primary sponsor for these technology areas.

The recommended course at this stage of development is for DTRA to provide some sponsorship, but more importantly, provide leadership in the form of working toward an interagency working agreement to assure its interests are protected and to speed the needed research by preventing overlap or duplication and identifying, with the other agencies, the most fruitful directions for new research.

## 2.0 Introduction

The High Energy S&T Workshop was a follow-on to the Novel Energetics Workshop but with the focus on energetic materials and phenomena whose energy is derived from the nucleus or subatomic processes. The Workshop objectives were to explore the following five potential areas of high-energy research:

- **Nuclear isomers**
- **Low energy nuclear reactions (LENR)**
- **Anti-matter annihilation**
- **Advanced nuclear fission and fusion concepts**
- **Exotic/extreme physics**

Only the first three topics are discussed in detail this report, because they were the primary focus of the Workshop and could be treated at the unclassified level.

The Workshop was structured to include a Panel of Experts, well versed in the topical areas and familiar with DTRA's missions and research portfolio. The Panel of Experts consisted of:

**The Honorable Harold Smith**, former DoD/ATSD(NCB) and currently a Distinguished Visiting Scholar and Professor at UC, Berkeley

**Dr. Jack Davis**, ST Executive, Plasma Physics Division, NRL

**Dr. Gerald Yonas**, Director, Advanced Concepts Office, Sandia National Laboratory

**Dr. Fred Wikner**, former OSD Director of Net Assessment and presently consultant to Applied Research Associates Inc.

The panel of Experts was instructed to screen and critique candidate high-energy S&T topics and provide recommendations regarding their maturity and relevance for DTRA.

The three topics of Nuclear Isomers, LENR, and Anti-Matter Annihilation were presented as Panel Discussions, starting with an overview by the Panel Chairman; followed by a detailed presentation by each panelist, and finally a discussion period with the Panel of Experts and the Workshop participants.

The following questions were posed for the discussion period:

- Should the high energy S&T topics be included as part of a balanced investment portfolio in "Disruptive Energetics?"
  - Do we understand the underlying physics sufficiently well to proceed with confidence?
  - Do the potential pay-offs outweigh the risks?

- What should be the focus of the investment?
  - Well-defined, refereed, repeatable experiments?
  - Proof-of-concept tests?
  - Theoretical investigations?
  - Other?
- What are the potential applications?
  - Could these topics underwrite game-changing improvements in warfighting?
- What are the potential risks?
  - How many orders of magnitude of the specific energy density is likely to be lost to system-level packaging?
  - What criticisms should we anticipate from scientists, from the DoD bureaucracy, from Congress, ...?
  - Will these topics bump up against nuclear arms control agreements?

### 3.0 Workshop Overview

The High Energy S&T workshop was held in the DTRA Headquarters Auditorium at Ft. Belvoir, VA. The first day was dedicated to unclassified work while the second day was maintained at the Secret CNWDI level to facilitate in-depth discussions on several of the topics.

#### 3.1 First-Day Agenda

The agenda for the first day is shown in Figure 1. Each of the three Panel Chairs provided a summation of their topical area followed by detailed briefings by each of the Panel members. Dr. Bob Park was invited to speak at lunchtime, where he provided a perspective for evaluating new and evolving scientific and technical concepts against risky assumptions and faulty premises.

Agenda – 12 Dec 2006 (Unclassified Session)		
0830	Admin & Introductory Remarks	ASCO Staff, SAIC Staff
0900	OSD Perspective	Spiro Lekoudis, DDR&E
0930	NNSA Perspective	Dave Crandall, NNSA
1000	Break	
1015	Panel 1 – Nuclear Isomers	Jim Silk, IDA (Panel Chair)
	James Carroll, Youngstown State	
	(b)(6)	
	Ehsan Khan, SIER Program Rep	
1215	Lunch	
	<i>Luncheon Talk: "A Skeptic's Viewpoint" Bob Park, UMD</i>	
1300	Panel 2 – LENR	David Nagel, GWU (Panel Chair)
	Mitchell Swartz, JET Energy Inc.	
	Michael Melich, NPGS	
	Lewis Larsen, Lattice Energy LLC	NET: Allan Widom spoke as well
1500	Break	
1515	Panel 3 – Anti-matter	Ken Edwards, AFRL/MN (Panel Chair)
	Allen Mills, University of California, Riverside	
	Gerry Smith, Positronics Research LLC	
	Paul Csonka, University of Oregon	
1715	Adjourn	

Figure 1. The Energy Workshop Agenda – Day 1

### 3.2 Second-Day Agenda

The second day included a perspective from the intelligence community, a review of an OSD-sponsored Net Assessment of Novel Energetics, and a discussion on the potential for 4<sup>th</sup> Generation Nuclear Weapons. Most of the presentations were classified. At the end of the day, the Expert Panel reported their individual observations and a “Hotwash” briefing was presented to the senior leadership of the DTRA. Figure 2 shows the agenda of the second day.

<b>Agenda – 13 Dec 2006</b> <b>(Session Classified)</b>		
0830	Intelligence Perspective	(b)(6)
0930	OSD Net Assessment (Blue Team)	
1015	Break	
1030	Exotic Energy and Power Concepts	Charles Rhodes, U of IL
1130	Lunch	
1230	Panel 4 – 4 <sup>th</sup> Generation Nuclear Weapons	Don Linger, DTRA Ed Turano, LLNL
1400	Break/Expert Panel Deliberations	
1430	Expert Panel Findings and Recommendations	
1530	Adjourn	
1600	Hotwash (Government Only)	
1700	Finis	

**Figure 2. The Energy Workshop Agenda – Day 2**

## **4.0 Perspectives from Government Officials**

**4.1 Dr. Mike Wheeler, DTRA Director of ASCO** welcomed all to the Workshop and provided additional context for the meeting. He spoke about the 2003 Summer Defense Science Summer Study on Future Strategic Systems, chaired by Johnny Foster. Three main themes emerged:

- a. Whether we maintain legacy nuclear weapons and/or develop new weapons (emerging technology). This debate regarding the composition of the stockpile is still ongoing.
- b. How to prevent strategic surprise from taking place by challenging the strategic community and policy community to look ahead at emerging technologies that could have military implications.
- c. What options can be given to the President to hold targets at risk without breaking the nuclear threshold – this effectively being a "holy grail" for the policy community.

He proceeded to explain how High Energy technologies fit within the DTRA research portfolio. DTRA has become the one place to concentrate all the nuclear weapons activities within the DoD. The Director of DTRA is also now dual-hatted as the Director of STRATCOM's Center for Combating WMD worldwide. DTRA has also just adopted a Campaign Structure whose topics are cross-cutting. He expressed his belief that High Energy technologies will contribute to several of these Campaigns.

**4.2 Dr. Spiro Lekoudis, DDR&E, Director for Weapons Systems**, referenced a comprehensive review of all DoD energetics research that was conducted the previous summer in response to Defense Planning Guidance and to support the POM and the Budget Estimate Submission (BES) process. He noted the gap between chemical energetics and nuclear energetics and how 50 years of research has only extended the chemical energy density by perhaps a factor of two. He acknowledged that some of the topics under consideration in this Workshop have the potential of narrowing that gap but he was circumspect about the prospect of additional funding to do so. While he recognized that the energetics community may be in distress, he placed some of the blame on the acquisition pipeline and the lack of awareness of the art of the possible. He lauded DTRA's initiative in conducting this Workshop and commented that he depends on such forums to gather the necessary information to make informed decisions. He cited the need for lighter, smaller, and more effective weapons as the primary motivator for advanced energetics, particularly in the context of difficult-to-defeat targets such as hardened bunkers and underground tunnels. He also expressed some frustration that DARPA R&D is not suited for long-term research even if the projects are "DARPA-hard." DARPA's mandate for prompt (3-year) transition to the warfighter limits their involvement in such pursuits as novel energetics.

**4.3 Dr. Chris Deeney, National Nuclear Security Administration (NNSA)** spoke for **Dr. Crandall** who was unavailable for the morning session. He expressed strong support for DTRA's program in trying to better understand nuclear weapon output and felt that more effort is needed here. As far as NNSA programs are concerned, the focus has been on the Reliable Replacement Warhead (RRW) and Complex 2030, which will provide the infrastructure to support our future nuclear stockpile. However, in today's environment anything nuclear is a tough sell and even the RRW is getting push-back from Congress.

He discussed the NNSA concerns about technology surprise in developing scientific fields related to high energy, high energy density, and high energy release rates. In this regard, he expressed concern about the decline in nuclear curricula at our universities and the dearth of U.S. students interested in pursuing the nuclear career field. This is not the case in Japan, Europe, and other parts of the world, where the leadership values nuclear power and recognizes the dual-use nature of the technology as a pathway to proliferation. He briefly described the NNSA Academic Alliance program, which seeks to reverse some of these unfavorable trends and demographics and train the next generation of scientists and managers for the nuclear enterprise.

In response to a question regarding NNSA-sponsored laser research, he commented that lasers and particle accelerators are fertile fields of research to meet future requirements. For example, he cited an important need for proton radiography.

In regard to other potential nuclear sources of energy, he felt that existing treaties and arms control protocols would get in the way, unless it is clear that there is zero yield from either fission or fusion processes. He noted that nuclear spin isomers might be exempt from current legal strictures, but the loophole will not likely last if such concepts are actively pursued.

## 5.0 Summary of Survey Presentations

### 5.1 Nuclear Isomers Panel

**Dr. Jim Silk , Institute for Defense Analysis (IDA)**, chaired the panel on Nuclear Isomers. An experimental nuclear physicist by training, he has been with IDA for 17 years, serving as the Deputy Director of the Science and Technology Division for the last four. He led the OSD-sponsored review of Nuclear Isomer Triggering in 2002, and served as a member of the Low Energy Nuclear Reaction Verification Red-Team.

Dr. Silk acknowledged the attractiveness of nuclear isomers given that their specific energy density is within a factor of a 100 of that of nuclear weapons. However, in his opinion, nuclear isomer research is still immature, energy break-even is improbable, and fuel production is likely to be harder than was the case for nuclear weapons. He discussed the experimental results and the reasons for difficulties in demonstrating energy gain and appropriate levels for triggering radiation release. These are related to the theoretical intractability of nuclear transitions and the crossover between natural low energy transitions and high energy depletion state thresholds. He summarized the current state of controversy regarding the  $\text{Hf}^{178\text{m}2}$  isomer by stating that he has not seen any evidence of observable triggering. His recommended path forward is shown in the panel below:

#### ***Path Forward***

- How to resolve the controversy?
  - Design a new (null) experiment?
  - Red team the data analyses? White team?
  - Let it play out?
- Beyond this, where should the research program go?
  - Nuclear structure studies - K-mixing mechanisms
  - Search for natural 2- $\gamma$  decays
  - Other isomers
  - Other triggering mechanisms
  - Diversify

Dr. Carroll, Youngstown State University, reviewed the basics of nuclear isomers and their induced depletion (he prefers this term in lieu of "triggering"). He presented a table of 32 storage isotopes having lifetimes measured in seconds to years, highlighting those that store the most energy for the longest time as potentially useful for DTRA applications. Dr. Carroll summarized the current work being performed as following one of two approaches: 1) performing nuclear spectroscopy to characterize the energy levels and transitions or 2) direct measurement of depletion of metastable states with gamma ray, neutron or heavy ion irradiation followed by detection of decay rates of discrete energies. He reviewed nuclear spectroscopy and depletion data for several interesting isomers. The panel below shows some of the more promising candidates having depletion paths or induced decay modes:

### ***REPORTED DEPLETION***

- $^{178m2}\text{Hf}$  – depletion paths identified (> 300 keV)
- $^{242m}\text{Am}$  – depletion paths available
- $^{108m}\text{Ag}$  – depletion path in literature (partial data)

### ***SPECTROSCOPY***

- $^{180m}\text{Ta}$  – photons, confirmed and connected to nuclear spectroscopy
- $^{178m2}\text{Hf}$  – photons near 10 keV – not confirmed or substantiated by spectroscopy
- $^{177m}\text{Lu}$  – neutrons, not confirmed
- $^{68m}\text{Cu}$  – photons (Coulomb excitation), not confirmed

- **THREE POSSIBLE CASES OF MEASURED DEPLETION**
- **THREE ADDITIONAL ISOMERS WITH DEPLETION PATHS**

The panel that follows is Dr. Carroll's summary of his views regarding the issues slowing progress:

## ***IMPEDIMENTS TO PROGRESS***

- **TIME** – experiments are typically difficult to perform and analyze
- **MATERIAL** – isomeric material needed in sufficient quantity for tests – purity typically insufficient for spectroscopic measurements as targets (isomer beams may solve this problem)
- **MANPOWER** – support needed to expand research dedicated to depletion tests and related spectroscopy
- **PERCEPTION** – latest depletion-related research considered solid, but nuclear physics community wary of extraordinary claims (as it should be).

**Dr. Ehsan Khan**, Department of Energy, Science Division, and former Program Manager for DARPA's Stimulated Isomer Energy Release (SIER) Program presented his perspective on the attractiveness of Nuclear Isomer Release Energy. Based on his experience with the Hafnium Isomer Production Panel (HIPP) he believes there are various feasible methods to increase production rates. He also believes that one of the drawbacks of past triggering experiments has been that the detection of low levels of triggered radiation is difficult in the presence of triggering radiation, other reactions, as well as electro-magnetic interference. Detecting the triggered radiation in such a complex background will need very careful experimental design.

**Dr. Schumer**, NRL, presented his perspective on why nuclear isomers/isotopes are intriguing energy-storage media. The question, which he believes remains unanswered, is whether nuclear isomers/isotopes can serve as a source of energy-on-demand? Dr. Schumer reviewed recent and proposed work at NRL, ARL and NSWC. He emphasized the need for a broader scope of research, including triggering using particles as well as gamma rays and showed some promising results under high current/ fluence, short duration pulsed particle beams, allowing measurement of product decay without the presence of the primary beam contributing noise.

His guidance on future isomer/isotope research is shown in the panel below:

**Nuclear isomers/isotopes are intriguing energy-storage media, but the question remains: can they be *energy-release* media?**

- Basic research is required before applications can be envisioned
- Efforts should be multi-faceted and multi-institutional
- Focus should expand beyond "Unobtainium" (i.e.  $^{178m2}\text{Hf}$ )
  - including pure spin-isomers (not K-hindered)
  - including electron-capture and internal conversion isotopes
- Experimental evidence should be:
  - tempered with theoretical expectations
  - "open" vetting by experts, including both peers and un-invested community ("open" is TBD by concerned agency)
- After confirmation, system study is still required to deem ready for real life (is efficiency good enough?)
- All of this is required before beginning Manhattan-style effort to produce material

**5.2 Low Energy Nuclear Reaction (LENR) Panel**

**Dr. David Nagel, George Washington University**, chaired the Low Energy Nuclear Reaction (LENR) Panel. He is a Research Professor in the School of Engineering and Applied Science of George Washington University. Dr. Nagel is a recognized authority on low energy nuclear reactions in condensed matter. He commented on the present state of LENR research, noting some of the more important problems impacting LENR research today:

## **PROBLEMS**

- **Potential Importance for Energy, Materials and Weapons**
- **Polarization of Scientists**
- **Diverse Mistakes**
- **Technical Complexity**
- **Flows of Money and Information Disrupted Early & Remain Poor**

On the other hand, Dr. Nagel pointed to many recent positive developments that indicate substantial progress in understanding and demonstrating LENR. He also mentioned the need for a theoretical basis to underpin experimental work.

## **PROGRESS**

- **Continuous Activity & International Conferences**
- **Better Instrumentation, Calibration and Controls**
- **Some Systematics Found & Verified for Heat Generation Experiments**
- **Nuclear Ash Measured & Correlated with Heat Production**
- **More Attention to Materials**
- **New Experiments Performed**
- **Some Inter-lab Reproducibility**

**Dr. Mitchell Swartz, JET Energy, INC** presented a brief summary of the results of excess heat experiments in electric-field loaded deuterated metals:

## **EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS**

**Research and Development**

### **BRIEF SUMMARY OF RESULTS:**

**SIGNIFICANT EXCESS HEAT OBSERVED IN PALLADIUM HEAVY  
WATER (PdD) SYSTEM, PALLADIUM HEAVY WATER (PdD)  
CODEPOSITIONAL SYSTEM, SOME NICKEL LIGHT and  
HEAVY/LIGHT WATER SYSTEMS**

**EXCESS HEAT NOT OBSERVED IN IRON, ALUMINUM, OR  
DAMAGED PALLADIUM NICKEL SYSTEMS**

©

**JET Energy, Inc.**

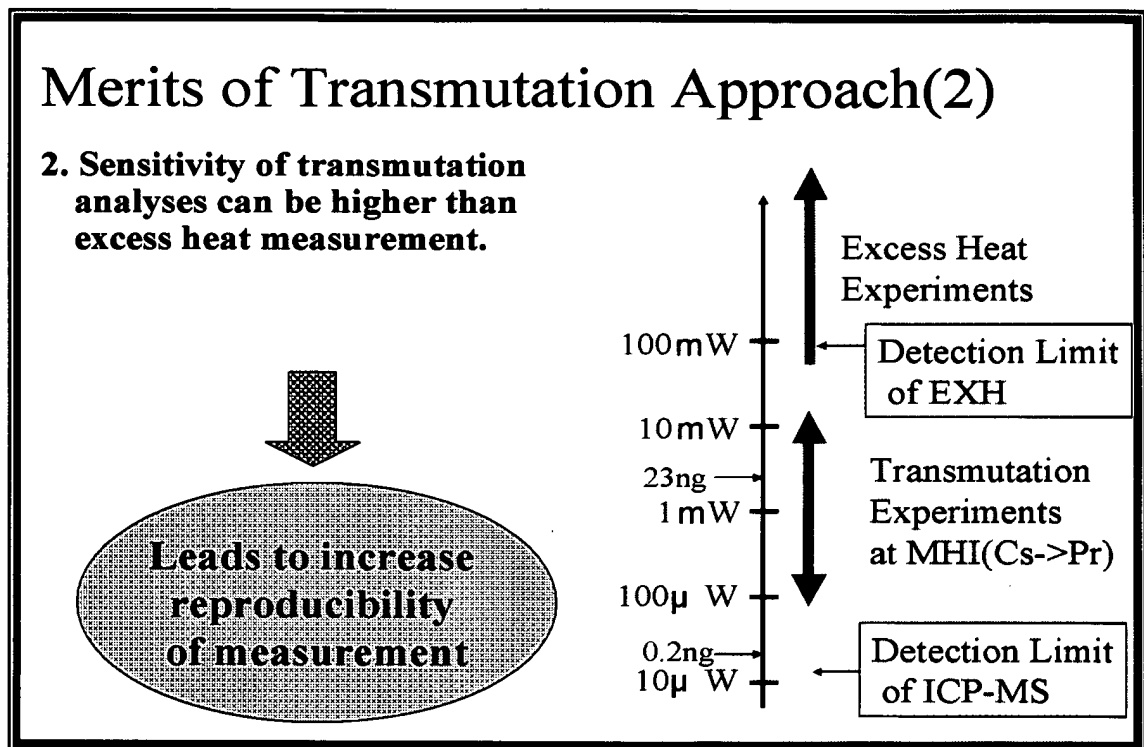


**DTRA ASCO Workshop  
on High Energy Science and Technology Dec.  
12, 2006**

He explained his methods for controlling measurement error and system noise by using dual calorimeter measurements that allowed precise differential measurement and integration of power. He was thus able to compare measurements of several different instruments to allow judgment of consistency in his reported results.

The diffusion and electrophoresis equations show the advantages of low conductivity electrolytes and relatively high voltages for loading D into the electrodes with co-deposition of electrode material. **Dr. Swartz** obtained energy and power gains over the D charging (loading) input power and discussed the importance of determining optimized operating points. Impressively, he showed a video demonstrating enough power to spin the propeller of a model airplane.

**Professor Michael Melich, W.E. Meyer Institute for Systems Engineering, Naval Postgraduate School**, talked about transmutation as the signal for detecting LENR using experiments conducted in a Deuterium cell with an electrolytic Pd diffusion barrier. Quantifying the transmutation products as an experimental approach potentially affords greater sensitivity and reproducibility than excess heat, since the new elements are not present initially and can be detectable in very small concentrations:



Recent trials confirmed that following standard electrolysis experiments, the diffusion barrier contained elements not present before the runs. In principle, the results of a single run can then be analyzed by other labs to determine the degree of consistency in detection of small concentrations of transmuted elements.

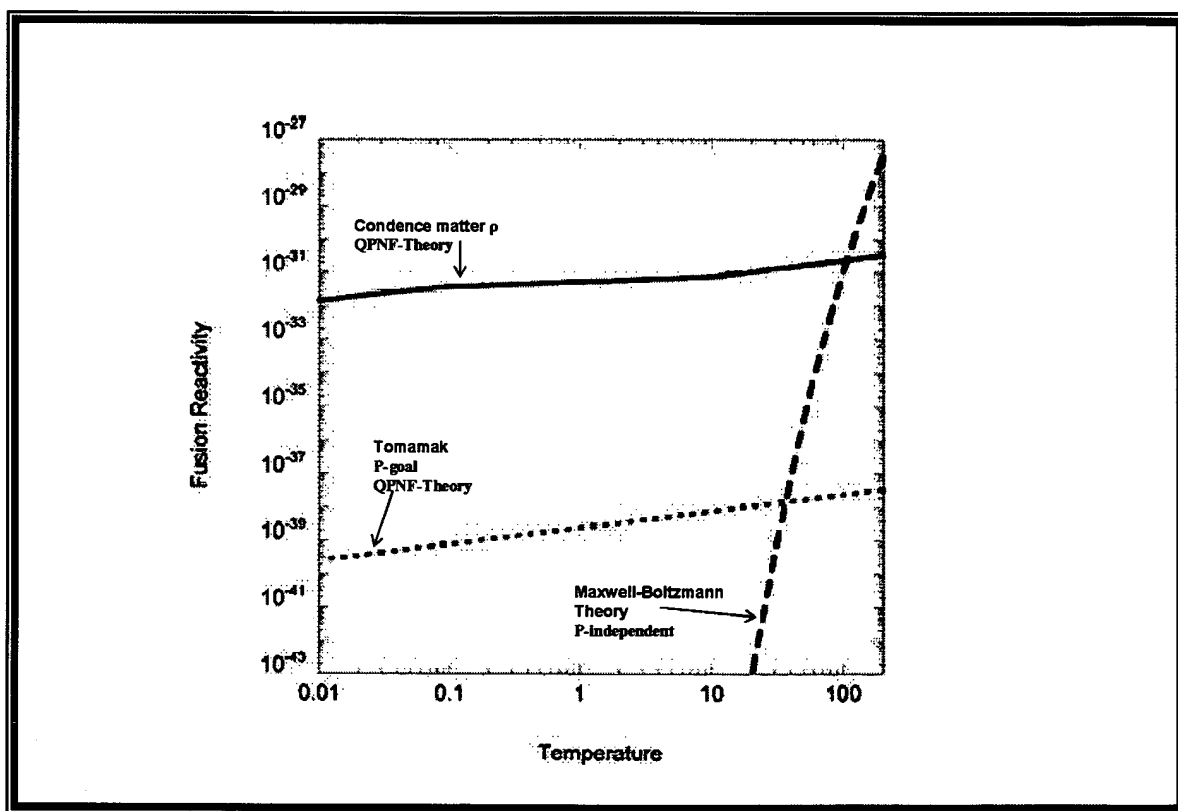
**Lewis G. Larsen, President and CEO, Founder and Prof. Allan Widom Consultant and Member of Lattice Energy LLC and Northeastern University, Dept. of Physics** presented proprietary material on the Widom-Larsen theory for metal hydride surface catalysis of LENR. A convincing thesis was advanced to describe many of the known features of LENR without invoking

any new physics. The theory is premised on the weak force (beta decay) of the Standard Model.

NET: Kim did not present on the 12th or 13th, though he was in the audience. He provided slides to DTRA after the meeting.

**Yeong E. Kim, Purdue Nuclear and Many-Body Theory Group, Department of Physics, Purdue University** described a theory based on Quantum effect broadening of the distribution (via the Gamow factor). For  $n(E)$  that is Maxwell-Boltzmann (MB), Fermi-Dirac (FD), or Bose-Einstein (BE) distribution, modified by the quantum broadening of the momentum-energy dispersion relation,  $\delta\gamma(E - \epsilon_p)$ , due to particle interactions.

The Quantum Nuclear Plasma Fusion theory provides a mechanism for enhanced net reaction rates at lower temperatures as illustrated for Deuterium-Deuterium:



### 5.3 Anti-Matter Annihilation Panel

**Mr. Ken Edwards, AFRL/MN**, chaired the Anti-Matter Panel. He is Director of the Revolutionary Technologies Integrated Product Team, chartered to plan and develop revolutionary paradigm-shifting munitions for the Air Force of 2025. He is currently focused on Positron Energy Conversion for explosive and propulsive applications and has overseen work in this area for several years. This has been a joint program conducted in partnership with DARPA.

Mr. Edwards listed the primary advantage of stored positrons to be their very high specific energy densities without creating any radioactive nuclear debris or long-term radiation following an annihilation reaction. Regarding storage mechanisms, he showed some schemes for efficiently moderating and storing positrons in the form of positronium (Ps) (a pseudo-atom consisting of a positron and an electron) using Penning traps. He noted that positronium can be stabilized using crossed magnetic and electric fields. Quantum chemistry calculations suggest potential lifetimes of up to a year or longer.

**Dr. Gerry Smith, Professor Emeritus (Physics), Penn State, and Positronics Research, LLC** reported on the "Physics and Experiments with Long Life Positronium" and described the theoretical basis for extended half-life of Ps in the crossed fields of a Penning trap. It was postulated that radiation-damaged Silica Aerogel (SA) might be paramagnetic and with controlled pore size, crossed fields (based on remnant magnetic fields and an imposed (modest) electric field) would allow storage of positronium for significant times at useful densities.

Dr. Smith summarized the work he felt would need to be accomplished to demonstrate this concept for anti-matter storage:

### Program Goals & Challenges (Near -Term)

Demonstrate improvements for higher density and longer -term Ps storage

- Intense, larger volume (10x)  $e^+$  irradiation of SA (>20 MGy)
- Test ultra light SA (> 100 nm cavity) and magnetized SA
- $e^+$  beam injection into Penning trap (20 mCi source)
- $e^+$  accumulation, cooling and lifetime ( $10^{-6}$ , 3 meV, > 20 sec)
- $e^+$  extraction into silica aerogel (5  $\mu$ sec)
- OWPs number enhancement (10 SA vol. x 30 field/temp = 300x @ 400G, 0.5K)
- OWPs density enhancements (30 field/temp/10 SA vol. = 3x @ 400G, 0.5 K)
- OWPs lifetime enhancement (TE; 100 nm, 1.2 ms = 100x; 1000 nm, 0.36 sec = 36,500x)

**Dr. Allen P. Mills, Jr., Physics Dept., University of California, Riverside, CA** proposed the need for apparatus to provide larger numbers of Ps atoms in order to study aspects of stimulated annihilation and their Compton wavelength. Dr. Mills described his program for a series of increasingly intense positron sources and showed calculation of their efficiency in producing Ps. A  $^{12}\text{C}(\text{d},\text{n})^{13}\text{N}$  reaction provides positrons when the nitrogen decays, which are then slowed and cooled in a Penning trap. His program may lead to development a 50 W source of positrons. The sources currently under way are in the milliwatt range.

Dr. Mills scientific objectives are to measure  $g$  for Ps, (needs  $10^8$  Ps); to observe stimulated annihilation, (needs  $10^{11}$  Ps); to make an annihilation gamma ray laser and measure the Compton wavelength, and to ignite fusion (perhaps  $10^{19}$  Ps). Larger sources and more refined positron moderating and cooling techniques will be required for Dr. Mills' more advanced planned sources.

### Stages to 50 W antimatter source

Year	Model	$\text{d}^+$ Energy	Current	slow $\text{e}^+/\text{s}$	
2008	HFPS-1	1.5 MeV	1 mA	no mod.	
2008	HFPS-2	1.5 MeV	1 mA	$10^9$	
2009	HFPS-3	5 MeV	1 mA	$10^{10}$	1.6 mW
2010	HFPS-4	5 MeV	10 mA	$10^{11}$	16 mW
2011	HFPS-5	30 MeV	10 mA	$3 \times 10^{12}$	0.5 W
201X	HFPS-X	30 MeV	1 A	$3 \times 10^{14}$	50W

HFPS-3 is about to enter Phase II.

HFPS-4 and 5 are suitable for a large lab.

HFPS-X might be possible.

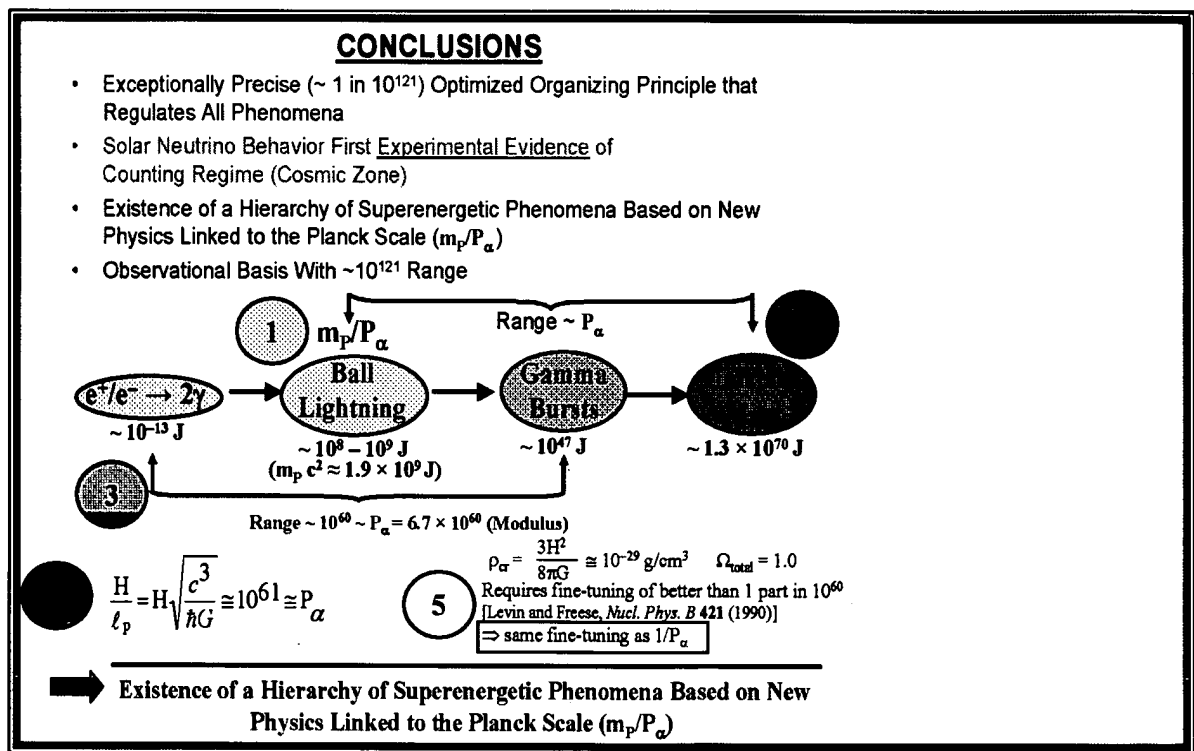
**Dr. Paul L. Csonka, University of Oregon,** spoke on the topic of "INTENSE POSITRON SOURCE with ENERGETIC ELECTRONS TRAVERSING UNDULATOR". He proposes positron generation using gamma rays from undulators mounted on major high energy storage rings. The main source of positrons (fast particles) seems to be pair production. He showed calculations of positron currents of between  $10^{14}$  and  $10^{17}$  per second and suggested the resulting

fast particles could be moderated with an efficiency of 0.001 to 0.1 by one or another of proposed schemes. Accelerators existing and planned for other purposes could be adapted relatively easily for high flux positron production.

## 6.0 Other Topics

### 6.1 Exotic Energy and Power Concepts

Dr. Charles Rhodes, University of Illinois, illustrated relationships between levels of energy, power density of known physical phenomena that covers a scale of  $1:10^{121}$  in known instances. While some parts of this range have been exploited, Dr. Rhodes points out that many other parts of this vast range are available for study, and potentially scalable to energetic applications of interest:



### 6.2 4<sup>th</sup> Generation Nuclear Weapons

Dr. Don Linger, DTRA, postulated a new generation (post-Cold War) that would have little-to-no fission yield and therefore would be both radiologically clean and (perhaps) treaty compliant. Such low yields could be used against tactical targets and hard targets as well as for high altitude weapon effects. The US must be cognizant of such capabilities and the implications of such weapons potentially in the hands of our adversaries, both near-peer and developing nations.

### 6.3 Intelligence Perspective

(b)(6) **Intelligence Community**, gave remarks on advanced energy sources from the intelligence perspective. He is aware of concerns for the US maintaining an ability to steer high quality research to topics and objectives critical for national security.

In a connected concern, he also spoke of the inability to pursue answers to important questions because of lack of technical understanding, the inability to properly prioritize issues and finally, a lack of qualified workers in these fields. He supported the advanced work being discussed in this workshop as both critical data to be acquired and as important training for the rising generation of scientists and engineers.

## 7.0 Feedback from Panel of Experts

The Honorable Dr. H Smith, Dr. Jack Davis, Dr. Fred Wikner, and Dr. Gerald Yonas served as subject matter experts and provided their overall review of the Workshop. Their findings and recommendations are summarized in the table below:

	<b>Advisory Board Findings</b>	<b>Advisory Board Recommendations</b>
<b>Isomers</b>	<ul style="list-style-type: none"><li>• Nuclear structure is complex and poorly understood</li><li>• Experiments are ad hoc- not systematic: some interesting data but no triggering observed</li></ul>	<ul style="list-style-type: none"><li>• Conduct large scale computer simulations like ASCI (not DTRA, NSF or DOE)</li><li>• Experiments-long term; guided by theory, funded by NSF and DOE</li></ul>
<b>LENR</b>	<ul style="list-style-type: none"><li>• There is good evidence of excess heat and transmutation</li><li>• New theory by Widom shows promise; collective surface effects, not fusion</li><li>• Low energy implantation of ions</li></ul>	<ul style="list-style-type: none"><li>• Careful experiments confirm and expand data base</li><li>• Expand theory field with more participants</li><li>• Other experiments included</li></ul>
<b>Anti-Matter</b>	<ul style="list-style-type: none"><li>• Systematic approach required: how to manage it</li><li>• Experiments will require substantial increments</li></ul>	<ul style="list-style-type: none"><li>• Not suitable for DTRA, a combat support agency.</li></ul>
<b>Nuclear Weapons</b>	<ul style="list-style-type: none"><li>• DoD needs low residual radiation weapon; DOE knows how to RDT and produce them</li></ul>	<ul style="list-style-type: none"><li>• US DOE should proceed; DOD should provide requirements</li></ul>
<b>General Observations</b>	<ul style="list-style-type: none"><li>• Agency staffs and services are increasingly risk adverse</li></ul>	<ul style="list-style-type: none"><li>• Defense research establishment must think creatively about new concepts</li></ul>

## 8.0 Workshop Summary

The High Energy Workshop endeavored to assemble the recognized experts in each of the energy categories to survey the state-of-art. The presentations did elucidate the state of science but of course were limited in depth based on time available. At the end of the Workshop, an early summary or "Hot Wash" debrief was presented to the senior DTRA leadership on the salient points made in the two days presentation. It is included in Appendix B.

**Nuclear Isomers** research has not yet provided evidence of reliable and effective triggering mechanisms. Production seems feasible, though engineering development is needed to scale up to practical amounts of material. The complexity of isomeric excited states and their induced depletion paths leads us not to expect too much from better theory or intense calculational efforts.

Yet, one cannot help but be intrigued by potentially gaining access to such highly energetic states for military applications. At this stage, modest investments related to the study of isomers and the physics of de-excitation would appear to be prudent. Also, improvements in experimental methods and diagnostic tools may be warranted.

Clearly, isomer production is not now the greatest roadblock to a proof-of-principal demonstration and should not be pursued at this time. A more fundamental issue is demonstration of a robust triggering approach. Here more experimental work is useful if focused on development of techniques for analyzing gamma spectra and measurement of depletion rates. Equally important would be innovative approaches to nuclear structure and transition probabilities. Weapons applications based on isomeric payloads are premature and should not be pursued.

**Low Energy Nuclear Reactions** are showing some remarkable progress with respect to energy (excess heat) production and transmuted element detection, but experiments remain only thinly reproducible. LENR also suffers from a basic lack of understanding of the governing physics.

There is also a compelling need for a theory that can explain production rates and lead to specific electrode treatments and electrolyte compositions and predictions of reaction power, energy and products. The Widom theoretical construct appears promising, but lacks robust experimental verification and rigorous peer review.

**NET:** Widom-Larsen theory published in peer-reviewed Eur. Phys. J. C nine months before, March 2001

The polarizing history of LENR is a detriment to expanding research efforts and it seems unlikely that deployable/useable devices could be expected within a five to ten year horizon. Some low-level funding by 6.1 agencies seems appropriate, both to exploit the possibility of a breakthrough and to monitor other (international) research in this field. Nonetheless, DTRA should not go it alone; rather, it should provide the leadership to build interagency-research consortia with a focus on fostering improved research facilities and rigorous experimental protocols.

**Anti-Matter** research has provided encouraging results to suggest that positrons, in the form of positronium, may be efficiently stored with reasonable lifetimes. Clearly, stable sources of Ps capable of generating intense gamma pulses could have numerous interesting military applications. Methods to package Ps with longer life times and useful densities will require considerable experimentation and development, as will achieving efficient and affordable positron production methods.

A modest 6.1 program would keep DTRA in play on any future decisions regarding the feasibility of weaponizing anti-matter.

**4<sup>th</sup> Generation Nuclear Weapons Concepts** appear to be attractive for a number of military objectives, especially in situations needing low yield and low residual radioactivity

(b)(3):10 USC 128

The military effectiveness of such weapons will need to be characterized in detail in concert with suitable concepts of operation. The policy implications, in terms of how such weapons may be used and whether they meet current legal strictures and arms control restrictions, must also be examined. In view of this concern, expressed by several members of the Expert Panel, a cursory review of the current legal definition of nuclear weapons was commissioned by DTRA and is provided in Appendix D.

Given the congressional restrictions on pursuing new nuclear weapons concepts, it is not clear what DTRA's role should be other than to stay abreast of new developments in this area, as a hedge against technology surprise and a new wave of proliferation. Also, a review of the potential implications to the U.S. national security posture, should such weapons be developed by others, would appear to be well advised.

A **Workshop Summary Report** briefing was compiled following the workshop and was presented to DTRA sponsors of the workshop. It is provided in Appendix C.

## 9.0 Recommendations

**Novel Energy Strategy:** The Expert Panel noted that there many potentially interested agencies and that DTRA, as a new 6.1 agency, will need to find its niche. It is recommended that DTRA form and/or participate in an Interagency Novel Energy Working Group. Partnering agencies would include DTRA, DOE/NSSA, the National Laboratories, DHS, DARPA, NSF, and the Service Labs. The charter would be to coordinate budgets for maximum return and chart a course that would accelerate development of advanced energy concepts.

**Isomer Energy Storage:** The extraordinary claims regarding the de-excitation of  $\text{Hf}^{178\text{m}2}$  appear to have been thoroughly discredited. Nonetheless, it may be warranted to fund some basic research to continue screening candidate isomers, to develop an improved understanding of the physics of isomer de-excitation, and to explore de-excitation methods other than x-ray stimulation. There are no likely near-term military applications of nuclear isomers.

**LENR:** LENR still suffers from negative publicity associated with Cold Fusion and is viewed as being conducted outside the domain of legitimate, mainstream science. Nonetheless, the persistent and increasingly repeatable demonstrations of excess heat and transmutation suggest that there is something here worth pursuing. DTRA should not do so alone, but rather foster consortia that would help bring discipline and rigorous experimental protocol to this field. Additionally, efforts to better understand the physics of LENR as well as the development of first-principle predictive models are encouraged.

**Anti-Matter:** The challenge of stable storage of positrons in the form of positronium may be surmountable but progress to date has been modest. Near-term applications of this technology appear to be ill-advised. Additionally, the large parasitic mass associated with the storage of positronium and the small amount that can be stored, even under the most optimistic projections, effectively limits the system-level energy density. Nonetheless, some basic 6.1 research should be invested in keeping the effort alive. Perhaps an alliance between DTRA and NSF would be useful in this regard.

**4<sup>th</sup> Generation Nuclear Weapons:** DTRA, in cooperation with NNSA and with the approval of OSD, should consider supporting a few pilot studies to explore the potential applications of 4<sup>th</sup> generation nuclear weapons to meet projected future national security needs, explore the potential impact of such weapons if they were to be used against U.S. forces or infrastructure, and examine their overall policy implications.

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**Appendix A  
Workshop Participants**

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**Appendix B**  
**Hot-Wash Briefing to DTRA**  
**December 13, 2007**

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***High Energy Workshop***

***Expert Panel Findings and Recommendations***

***12-13 December 2006***  
***Defense Threat Reduction Center***  
***Fort Belvoir, VA***



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## Findings & Recommendations Isomers

- Findings
  - Nuclear structure is complex and poorly understood
  - Experiments ad-hoc – not systematic
    - Some good data
    - Hafnium triggering inconclusive and not energetically break-even
- Recommendations
  - Theoretical structure and reaction studies are needed
  - Experiments –Long-term, guided by theory, red-teamed

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## Findings & Recommendations LENR

- Findings
  - Good evidence of excess heat and transmutation
  - Widom-Larsen theory shows promise: collective surface effects ... not fusion
  - Low energy implantation of ions
- Recommendations
  - Careful experiments to confirm data base
  - Expand theory field – need more players
  - Other experiments warranted

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## **Findings & Recommendations Anti-matter**

- Findings
  - System approach required: How big is it??
  - Experiments will require substantial investments
- Recommendations
  - Not suitable for DTRA, a combat support agency

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## **Findings & Recommendations Nuclear Weapons**

- Findings
  - DoD needs low residual radiation weapons
  - DOE knows how to
    - RDT&E and Production
- Recommendations
  - DOE should proceed
  - DoD should provide requirements

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## Findings & Recommendations

### General Observation

- Finding
  - Agency staffs and Services are increasingly risk adverse
- Recommendation
  - Defense research establishment must think creatively about new concepts

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## Appendix C

### Summary Report Of High Energy Workshop

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## High Energy Workshop

### Sponsored by DTRA/ASCO

*12 – 13 December 2006*  
*Defense Threat Reduction Center*  
*Ft. Belvoir, VA*

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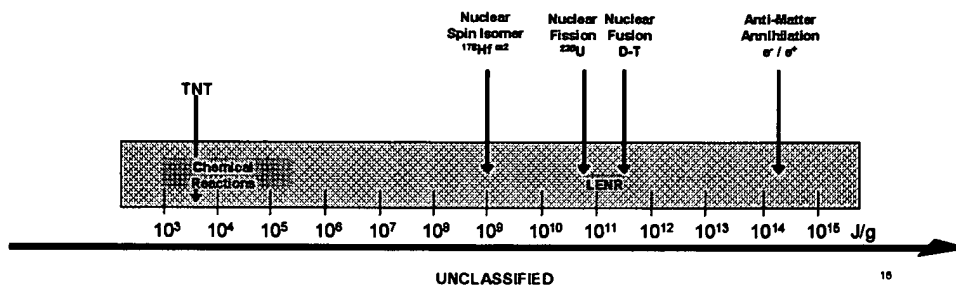
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## Workshop Objectives



- Survey and assess the S&T of highly energetic materials, whose energy is released via nuclear and subatomic processes ( $> 10^6$  eV/unit-event)
  - Nuclear Isomers
  - Low energy nuclear reactions (LENR)
  - Anti-matter Annihilation
  - Advanced nuclear fission and fusion
  - Exotic/Extreme Physics



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## Key Considerations



- Should these topics be included as part of a balanced investment portfolio in "Disruptive Energetics?"
  - Do we understand the underlying physics sufficiently well to proceed with confidence?
  - Do the potential pay-offs outweigh the risks?
- What should be the focus of the investment?
  - Well-defined, refereed, repeatable experiments?
  - Proof-of-concept tests?
  - Theoretical investigations?
  - Other?
- What are the potential applications?
  - Could these topics underwrite game-changing improvements in warfighting?
- What are the potential risks?
  - How many orders of magnitude of the specific energy density is likely to be lost to system-level packaging?
  - What criticisms should we anticipate from scientists, from the DoD bureaucracy, from Congress, ...?
  - Will these topics bump up against nuclear arms control agreements?

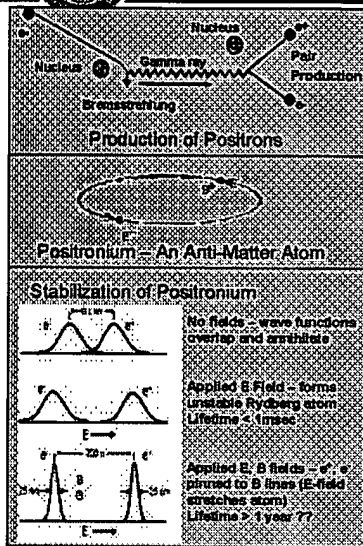
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## Anti-matter – The Basics



- Positrons annihilate with free electrons producing two soft (0.51 MeV) gamma rays (no radioactive products/residues)
  - Energy density for PEC is  $1.8 \times 10^{14}$  J/g, compared to  $4.7 \times 10^3$  J/g for TNT and  $8.2 \times 10^{10}$  J/g for  $^{235}\text{U}$  fission
  - 1  $\mu\text{g}$  of positrons ~40 kg of TNT
- Positrons produced via bremsstrahlung and pair production (requires linac or synchrotron)
- Positrons stored as neutral positronium
  - No space charge forces to deal with
  - Positronium stabilized by crossed E and B fields
  - Quantum theory predicts stable Coulomb states of positronium with lifetimes of one year or longer
  - Ps storage in Penning traps and silica aerogels
- Potential applications include blast-frag effects, EMP, gamma ray laser, bioagent defeat, propulsion etc.

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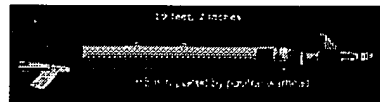
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## DARPA Proposed Applications for Positronium Payload\*



- A non-nuclear near-miss-to-kill interceptor for ballistic and cruise missile defense
  - Direct hit not necessary
  - Radiation kill of electronics and bioagents
  - 0.3 ns risetime (b)(3):10 USC prevents circumvention
  - One  $\mu\text{g}$  burst can be lethal to 300m against unshielded electronics (upset & latchup); other lethality mechanisms operate at shorter ranges
  - Only millisecond collateral RF interference effects
- A killer of bioagents in small bunkers
  - Promptly kills bioagents prior to dispersal
  - 1  $\mu\text{g}$  burst has a lethal radius of 2 meters against anthrax, the hardest case (radius for rendering sterile is greater)



\* Briefing by Martin Stickley, 5 June 2006

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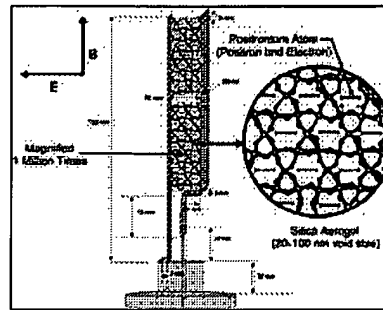
## Technical Challenges



The DARPA Ps Weapon Prototype consists of  $10^{21}$  positrons stored (as Positronium), at a density of  $1 \mu\text{g/liter}$ , with an energy equivalent of 180 MJ (40 kg TNT, 25x volumetric)

### Challenges

- Positronium production
  - Plant capital and operating costs (\$77M - \$200M per year)
  - Output of  $10^{22}$  to  $10^{24}$  Ps per year
- Long-term Ps storage (30 yrs) at militarily useful densities (180 MJ/l)
  - Create stable states of Ps that prevent self-annihilation
  - Penning trap for accumulation and cooling
  - Silica aerogel storage for weapons application
- Cost per weapon
  - \$200K - \$1.5M



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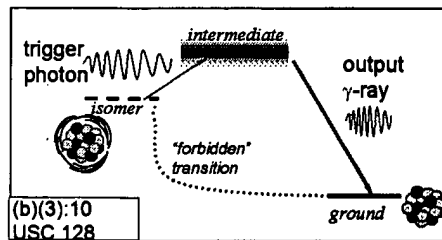
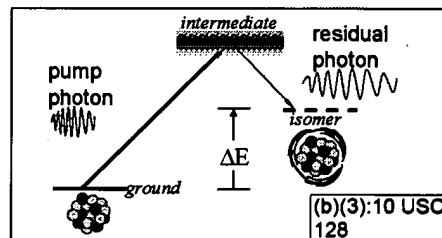
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## Nuclear Isomers – The Basics



- Nuclear isomers are metastable excited nuclear states with energy densities approaching nuclear fission (up to  $10^9$  J/g for isomers vice  $10^{11}$  J/g for nuclear fission)
- Nuclear isomers are long lived with mean lifetimes ranging from a few  $\mu\text{sec}$  to 1000s of years
- Fuel production is harder than for SNM
- Isomers can be de-excited to release energy by x-rays, neutrons, ions, ...
  - Demonstrated in  $^{180}\text{Ta}$  and  $^{187}\text{Au}$
  - Triggering physics not well understood
  - Energy break-even is improbable
- Potential applications
  - Weapons and portable energy sources if triggering energy is low



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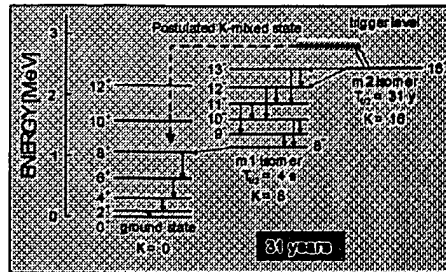
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## The Hafnium Controversy

**SAIC**  
 Plans. Surveys. Solutions.

- $^{187}\text{Hf}^{m2}$  is attractive isomer
  - 2.4 MeV above ground state
  - Half-life of 31 years
- In 1999 collaboration led by Carl Collins (UT, Dallas) reports in Phys Rev Letters evidence that 10-keV x-ray photons can de-excite  $^{187}\text{Hf}^{m2}$ , triggering a prompt cascade of 2.45-MeV gamma-rays
  - Claimed existence of k-mixed state some 20-60 keV above the m2 state
- All attempts to reproduce Collin's results failed
- Strong theoretical arguments against triggering of  $^{187}\text{Hf}^{m2}$ 
  - Isomer is in high spin state ( $J=16, K=16$ ) – selection rules for E-M decay severely inhibit transitions with large changes in K
  - Theoretical nuclear x-ray absorption cross sections too low by  $\times 10^6$
- Even if triggering were possible, difficult to envisage chain reaction for explosive applications



### Where to next?

- Achieve closure for  $^{128}\text{Hf}^{m2}$  ??
- Nuclear structure studies (K-mixing)
- Other isomers
- Other triggering mechanisms

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## Potential Isomers for Consideration

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 Plans. Surveys. Solutions.

Isomer	$T_{1/2}$ (yr)	$E_{\text{isomer}}$ (keV)	$E_{\text{trigger}}$ (keV)	Availability
$^{107}\text{Ag}$ $^{109}\text{Ag}$	418 0.68	109 118	46.4 72.9	$^X\text{Ag}(n,\gamma)^X\text{Ag}$ (51.8% $^{107}\text{Ag}$ , 48.1% $^{109}\text{Ag}$ )
$^{180\text{m}}\text{Ta}$	infinite	75	1010, 2800	0.012% of natural Ta (4.1% enriched from ORNL)
$^{242\text{m}}\text{Am}$	141	49	4, 99	$^{241}\text{Am}(n,\gamma)^{242\text{m}}\text{Am}$ (~1 g $^{241}\text{Am}$ from ORNL)
$^{168\text{m}}\text{Ho}$	1200	6	264	$^{168\text{m}}\text{Ho}$ fully-enriched from ORNL
$^{188\text{m}}\text{Re}$	$2 \times 10^5$	149	37	$^{185}\text{Re}(n,\gamma)^{188\text{m}}\text{Re}$ (96% enriched $^{185}\text{Re}$ from ORNL)
$^{177\text{m}}\text{Lu}$	0.44	970	100	$^{176}\text{Lu}(n,\gamma)^{177\text{m}}\text{Lu}$ (75% enriched $^{176}\text{Lu}$ from ORNL)
$^{187\text{m}}\text{Hf}$	31	2446	10	$10^9$ g quantities from SRS Technologies, Huntsville, AL

\*Source: Joe Shumer, NRL

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## Low Energy Nuclear Reactions (LENR)

**SAIC**  
Science Applications, Inc.



- Two branches of LENR

- Excess Heat
- Nuclear Transmutation

NET: This is incorrect. The hypothesis of "two branches" is obsolete. Excess heat occurs in both D/Pd as well as Ni/H. So do transmutations.

- Legitimate experiments by reputable researchers worldwide continue to demonstrate "excess heat" production in electro-chemistry experiments
- Other "chemistry" experiments have shown transmutation of elements and production of energetic tritons, helium and tritium
- None of these observations can be attributed to conventional chemistry
- The body of evidence supporting LENR continues to grow, but hard data still only thinly reproducible

Question: Why have LENR researchers not been killed by lethal doses of neutrons and gammas??

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## New Theoretical Developments Widom-Larsen Theory

**SAIC**  
Science Applications, Inc.

*Purports to explain most LENR observations without invoking any new physics beyond the standard model.*

- LENR is a manifestation of the weak interaction – it is not fusion or other forms of strong interaction
- Many-body "patches" of collectively oscillating protons or deuterons form on metallic hydride surfaces loaded with hydrogen isotopes
- Collective oscillations of the protons/deuterons start to loosely couple to the collective oscillations of nearby surface plasmon polariton (SSP) electrons, commonly found on the surface of metals
- Coupling between the two increases the local electric field to  $>10^{11}$  V/m (about the same as the Coulomb fields seen by inner electrons)
- Intense local radiation field raises effective mass of SSP electrons so that they can react with nearby protons and deuterons to form neutrons
- Neutrons created collectively have huge quantum mechanical wavelengths and are almost always absorbed by nearby nuclei
- Gammas emitted as a result of neutron absorption are intercepted by SSP electrons and reradiated as much softer E-M energy

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## Widom-Larsen Theory Explains ...



- Excess heat in electrochemical cells
- Nuclear transmutation abundances in electrochemical cells (total rates shown to be in agreement with experiment)
- Transmutations observed in exploding wire experiments as early as 1922

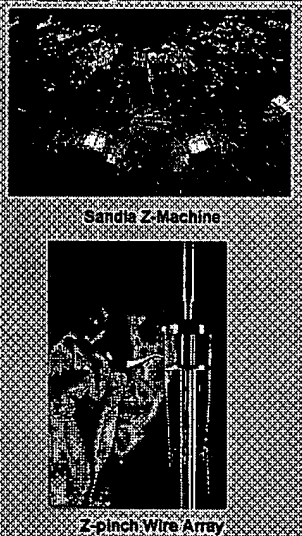
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## Advanced Nuclear Weapons Concepts



- Tailored Output Devices
  - Nuclear-driven directed energy
    - X-ray laser
    - Kinetic projectile array
  - Enhanced radiation weapon
  - Enhanced, localized EMP
- Pure Fusion Device
  - DT pellet implosion
    - Enhanced energetic material direct drive
    - Plasma Z-pinch drive
  - Essentially fall-out free
    - Some short-lived, neutron-activated radioactive isotopes

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## Other Exotica



- **Dark Matter**
  - Comprises about 22% of mass/energy of universe
    - Inferred from the motion of galaxies
    - Governed the earlier deceleration of the expanding universe
    - Many aspects of dark matter remain speculative
    - Density of dark matter is miniscule ( $10^{-29}$ g/cc)
- **Dark Energy**
  - Comprises about 74% of mass/energy of universe
    - Governs currently observed acceleration of expanding universe
    - Permeates and fills all space homogeneously
    - Density of dark energy is miniscule ( $10^{-29}$ g/cc)
- **Mini Black Holes**
  - A black hole of the smallest possible mass as determined by quantum mechanics
    - A degenerate state caused by runaway evaporation due to Hawking radiation
  - Mass is of order Planck's mass ( $2 \times 10^{-8}$  kg), or  $1.1 \times 10^{19}$  GeV, or 1.8 GJ (900 lbs TNT)
  - Further study warranted

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## Appendix D

# STATUTORY & TREATY REFERENCES TO NUCLEAR WEAPONS DEVELOPMENT

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## **STATUTORY & TREATY REFERENCES TO NUCLEAR WEAPONS DEVELOPMENT**

### **U.S. NUCLEAR WEAPONS OBLIGATIONS UNDER INTERNATIONAL LAW**

#### **Nuclear Non-proliferation Treaty (NPT) of 1968**

Often referred to as the “cornerstone” of international nuclear non-proliferation doctrine, the NPT embodies the aspiration to “facilitate the cessation of the manufacture of nuclear weapons” and work toward “general and complete disarmament” among nations.<sup>1</sup> In spite of the U.S. government’s frequent invocation of this treaty in diplomatic pronouncements, it continues to take actions relating to the design and production of new nuclear weapons, notably the Reliable Replacement Warhead (RRW) concept and the Robust Nuclear Earth Penetrator (RNEP) program.

During the 2000 NPT Review Conference, the five NPT-established permanent nuclear powers (U.S., U.K., China, Russia and France) restated the NPT goal of eventual nuclear disarmament, reaffirming their “unequivocal commitment to the ultimate goals of a complete elimination of nuclear weapons and a treaty on general and complete disarmament...” The P-5 statement further reiterates “the necessity of a... convention banning the production of fissile material for nuclear weapons or other nuclear explosive devices...”<sup>2</sup> While the NPT-recognized nuclear powers are thereby technically permitted to continue developing novel nuclear weapons in the absence of such a compact, doing so is widely considered antithetical to the spirit of the NPT. An additional product of the 2000 NPT Review Conference was the adoption of 13 “practical steps” toward the implementation of Article VI of the NPT concerning eventual nuclear disarmament. Research undertakings aimed at exploring new classes of nuclear weapons may violate one or more of these steps, including the agreement to move toward a “diminishing role for nuclear weapons in security policies... and to facilitate the process of their total elimination.”<sup>3</sup>

In a February 3, 2005, speech concerning U.S. compliance with Article VI, Assistant Secretary of State for Arms Control Stephen G. Rademaker, while highlighting reductions of U.S. nuclear stockpiles and the cessation of fissionable material production for nuclear weapons, issued a controversial reservation. Referring to an improved earth-penetrating capability, he made clear that the U.S. would “continue to plan for contingencies and conceptually explore technical options that could maintain the

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<sup>1</sup> Article VI, NPT: <<http://www.fas.org/nuke/control/npt/text/npt2.htm>>

<sup>2</sup> P-5 Statement on 2000 NPT Review Conference: <<http://www.ceip.org/programs/npp/npt2000p5.htm>>

<sup>3</sup> 2000 NPT Review Conference Final Document: <[http://www.armscontrol.org/act/2000\\_06/docjun.asp](http://www.armscontrol.org/act/2000_06/docjun.asp)>

credibility of our nuclear deterrent capability. Looking at options says nothing about what we will do. The fact is that the United States is not developing any new nuclear weapons, including low-yield nuclear weapons. The study of new weapons designs under funding provided by Congress in past years for advanced concepts has been entirely conceptual.” Rademaker emphatically repeated that the U.S. spends “zero – let me repeat – zero dollars” on the development or production of new nuclear weapons.<sup>4</sup> During a May 20, 2005, committee of the 2005 NPT Review Conference, Ambassador Jackie W. Sanders, Special Representative of the President for the Non-Proliferation of Nuclear Weapons, echoed Rademaker’s tone, pointedly asserting that “the United States is not, repeat not, developing new nuclear weapons.”<sup>5</sup>

The RRW program has been criticized for violating the spirit of Article VI. Funding for this program in the FY06 Energy and Water Appropriations Act stipulated that, “any weapon design work done under the RRW program must stay within the military requirements of the existing deployed stockpile and any new weapon design must stay within the design parameters validated by past nuclear tests.”<sup>6</sup>

### **Comprehensive Test Ban Treaty of 1996**

The principal objective of the CTBT is to limit global nuclear proliferation by denying nuclear weapons states the ability to achieve technical advancements that require testing to verify. While the U.S. is a signatory to the CTBT, the Senate has not ratified the treaty. However, the 1992 Hatfield Amendment established a nuclear testing moratorium in keeping with the spirit of the CTBT. This moratorium remains in effect.

While the CTBT explicitly bans “any nuclear weapon test explosion or any other nuclear explosion,” considerable ambiguity exists concerning the technical definition of these terms.<sup>7,8</sup> Indeed, a 1987 Los Alamos National Laboratory report notes that, “a nuclear explosion has never been defined officially...”<sup>9</sup> Less ambiguous is the preamble to the treaty, which recognizes that the cessation of nuclear test explosions is necessary for “constraining the development and qualitative improvement of nuclear weapons and ending the development of advanced new types of nuclear weapons...”

### **Other Cold War Treaties**

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<sup>4</sup> Rademaker remarks, “U.S. Compliance With Article VI of the Non-Proliferation Treaty (NPT)”:  
<<http://www.state.gov/t/ac/rls/rm/41786.htm>>

<sup>5</sup> Sanders remarks, 2005 NPT Review Conference: <[http://www.un.int/usa/05\\_100.htm](http://www.un.int/usa/05_100.htm)>

<sup>6</sup> FY06 E&W Appropriations Act, P.L. 109-275: <<http://thomas.loc.gov/cgi-bin/cpquery/T?&report=hr275&dbname=109&>>

<sup>7</sup> CTBT text: <[http://www.ctbto.org/treaty/treaty\\_text.pdf](http://www.ctbto.org/treaty/treaty_text.pdf)>

<sup>8</sup> Jones, von Hippel, “The Question of Pure Fusion Explosions Under the CTBT,” *Science & Global Security*, 1998, Volume 7, pp. 129-150:

<[http://www.princeton.edu/~globsec/publications/pdf/7\\_2Jones.pdf](http://www.princeton.edu/~globsec/publications/pdf/7_2Jones.pdf)>

<sup>9</sup> Thorn, Robert N. and Westervelt, Donald R. “Hydronuclear Experiments,” Los Alamos National Laboratory, February 1987: <<http://www.fas.org/sgp/othergov/doe/lanl/docs1/00090266.pdf>>

In the texts of the Strategic Arms Limitation Talks treaties (SALT I and II), references to nuclear weapons are oblique, though commonly understood. The treaties instead refer to “strategic offensive arms,” “ballistic missiles,” and “ICBMs.” The understanding that these terms refer to nuclear weapons is implicit. In SALT I, the word “nuclear” appears only once – in reference to the title of the NPT.<sup>10</sup> In SALT II, the parties recognize the devastating consequences of “nuclear war” and agree to “exercise restraint in the development of new types of strategic offensive arms.”<sup>11</sup> In both the Strategic Arms Reduction Treaties (START I and II), references are made to “nuclear armaments” and the means for delivering them – heavy bombers, ALCMs, and so on – without offering a precise definition of “nuclear.”<sup>12,13</sup> Likewise, the Anti-Ballistic Missile Treaty of 1972 makes reference to “strategic arms” and “strategic ballistic missiles” in the context of preventing “nuclear war.”<sup>14</sup>

The Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil Thereof (Seabed Treaty) of 1972 prohibits the deployment of “any nuclear weapons or any other types of weapons of mass destruction” on the seabed, the ocean floor or in the subsoil.<sup>15</sup> The Limited Test Ban Treaty (LTBT) of 1963, also known as the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (or the Partial Test Ban Treaty), invokes the desire to “put an end to the contamination of man’s environment by radioactive substances,” a broad definition that bans not simply nuclear weapon test explosions, but “any other nuclear explosion.” The treaty further prohibits any nuclear explosion that “causes radioactive debris to be present outside the territorial limits of the state under whose jurisdiction or control such explosion is conducted.”<sup>16</sup>

The Threshold Test Ban Treaty (TTBT) of 1990, seeking the “cessation of the nuclear arms race” and reductions in “strategic arms” and eventual “nuclear disarmament,” prohibits “any underground nuclear weapon test having a yield exceeding 150 kilotons.” Article III of the treaty specifically permits “underground nuclear explosions carried out by the parties for peaceful purposes,” wherein the term “explosion” is defined as “the release of nuclear energy from an explosive canister.”<sup>17</sup> An outgrowth of Article III was the Peaceful Nuclear Explosions Treaty (PNET) of 1976, which seeks to “assure that underground nuclear explosions for peaceful purposes shall not be used for purposes related to nuclear weapons.” Under this treaty, the parties agreed to “prohibit, to prevent and not to carry out...any explosion which does not carry out a peaceful application...” excepting tests permitted under the provisions of the TTBT.<sup>18</sup> The Strategic Offensive Reductions (SORT) Treaty of 2002 sought to reduce and limit “strategic offensive arms”

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<sup>10</sup> SALT I text: <<http://www.fas.org/nuke/control/salt1/text/salt1.htm>>

<sup>11</sup> SALT II text: <<http://www.state.gov/www/global/arms/treaties/salt2-2.html>>

<sup>12</sup> START I text: <<http://www.state.gov/www/global/arms/starthtm/start/start1.html>>

<sup>13</sup> START II text: <<http://www.fas.org/nuke/control/start2/text/treatyar.htm>>

<sup>14</sup> ABM Treaty text: <<http://www.state.gov/www/global/arms/treaties/abm/abm2.html>>

<sup>15</sup> Seabed Treaty text: <[http://www.nti.org/e\\_research/official\\_docs/inventory/pdfs/%5Captseabd.pdf](http://www.nti.org/e_research/official_docs/inventory/pdfs/%5Captseabd.pdf)>

<sup>16</sup> LTBT text: <<http://www.state.gov/t/ac/trt/4797.htm>>

<sup>17</sup> TTBT text: <<http://www.state.gov/t/ac/trt/5204.htm>>

<sup>18</sup> PNET text: <<http://www.fas.org/nuke/control/pnet/text/pne2.htm>>

and “strategic nuclear warheads.”<sup>19</sup> This treaty was criticized in some quarters due to the ambiguity associated with the term “strategic *nuclear* warheads,” which differed from the term “warheads attributed to strategic delivery systems” used in the START I Treaty.<sup>20</sup>

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## **U.S. GOVERNMENT NUCLEAR WEAPONS POLICY**

### **Atomic Energy Act of 1947**

Sec. 4 of the Act prohibits the possession or operation of facilities “for the production of fissionable material in quantities or at a rate sufficient to construct a bomb or other military weapon” outside the control of the Atomic Energy Commission (AEC). Later, in Sec. 6 the law prohibits the manufacture, production or possession of the means to “utilize fissionable materials as a military weapon, except as authorized by the Commission.” The law also forbids “any research or developmental work in the military application of atomic power if such research or developmental work is contrary to any international agreement...”<sup>21</sup>

### **Atomic Energy Act of 1954**

Sec. 91 of the Act grants authority to the AEC to “conduct experiments and do research and development work in the military application of atomic energy” and “engage in the production of atomic weapons, or atomic weapon parts...” The term “atomic energy” is defined as “all forms of energy released in the course of nuclear fission or nuclear transformation.”<sup>22</sup> The term “atomic weapon” is defined as “any device utilizing atomic energy, exclusive of the means for transporting or propelling the device...the principal purpose of which is for use as, or for development of, a weapon, a weapon prototype, or a weapon test device.”<sup>23</sup>

Sec. 51 provides for the eventuality that “the Commission may determine from time to time that other material is special nuclear material in addition to that specified in the definition as special nuclear material. Before making any such determination, the Commission must find that such material is capable of releasing substantial quantities of atomic energy and must find that the determination that such material is special nuclear material is in the interest of the common defense and security, and the President must have expressly assented in writing to the determination.”<sup>24</sup>

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<sup>19</sup> SORT treaty text: <<http://www.whitehouse.gov/news/releases/2002/05/20020524-3.html>>

<sup>20</sup> Center for Arms Control, Energy and Environmental Studies: <<http://www.armscontrol.ru/start/sort.htm>>

<sup>21</sup> P.L. 79-585: <<http://www.osti.gov/atomicenergyact.pdf>>

<sup>22</sup> Title 42, Section 2014c, U.S. Code

<sup>23</sup> Title 42, Section 2014d, U.S. Code

<sup>24</sup> Title 42, Section 2071, U.S. Code

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The Act grants to the President the right to “direct the Commission to (1) deliver such quantities of special nuclear material or atomic weapons to [DoD] for such use as he deems necessary in the interest of national defense, or (2) to authorize [DoD] to manufacture, produce, or acquire any atomic weapon or utilization facility for military purposes: Provided, however, That such authorization shall not extend to the production of special nuclear material other than that incidental to the operation of such utilization facilities.”

### **Additional definitions**

The Nuclear Waste Policy Act of 1982 includes in its definition of “atomic energy defense activity” the following: “weapons activities including defense inertial confinement fusion...”<sup>25</sup>

According to Section 2332a of Title 18, U.S. Code, the definition of “weapon of mass destruction” includes the following category: “(D) any weapon that is designed to release radiation or radioactivity at a level dangerous to human life...”<sup>26</sup>

### **1953 Agreement – Department of Defense-Atomic Energy Commission**

In 1953 an agreement was established between the AEC and the DoD to delineate the responsibilities of the respective agencies concerning “programs for proposed atomic weapons, their development, test, standardization, and production in accordance with military requirements.” The agreement states that the “development and production of atomic weapons will be the complementary responsibilities of the AEC and the DoD”; the “development and production of nuclear systems [defined as “comprised of the fission and/or fusion material, together with those components required to convert the system from the safe condition to an explosion”] is the primary function of the AEC”; the “division of responsibilities for the development and production of atomic weapons... will be by joint agreement on each weapon or by classes of weapons between the AEC and DoD”; and that the “determination of military characteristics suitability, and acceptability... is a primary function of the DoD.” The agreement also maintains that “it is fundamental to progress that both agencies pursue aggressively the study of new and radical concepts for military application of atomic energy.”<sup>27</sup>

The 1953 agreement identifies six phases of nuclear weapons production:

- 1) **Weapon conception** (may be undertaken independently or jointly; either agency that wishes to pursue an idea which would involve the modification of or the new development of nuclear systems must ask the other agency to examine the practicality of at least that portion of development)

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<sup>25</sup> Title 42, Section 10101, U.S. Code

<sup>26</sup> Title 18, Section 2332a, U.S. Code:

<[http://www.law.cornell.edu/uscode/search/display.html?terms=2332a&url=/uscode/html/uscode18/usc\\_sec\\_18\\_00002332--a000-.html](http://www.law.cornell.edu/uscode/search/display.html?terms=2332a&url=/uscode/html/uscode18/usc_sec_18_00002332--a000-.html)>

<sup>27</sup> 1953 Agreement: <[http://www.dod.mil/pubs/foi/reading\\_room/750.pdf](http://www.dod.mil/pubs/foi/reading_room/750.pdf)>

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- 2) **Determination of Feasibility** (may be undertaken independently or jointly; DoD determines military characteristics of weapon)
- 3) **Development Engineering** (AEC launches a development program, produces prototypes; DoD gives guidance)
- 4) **Production Engineering** (AEC proceeds with production of weapon; DoD gives guidance, evaluates prototypes as necessary)
- 5) **First Production** (AEC manufactures weapon; DoD makes evaluation)
- 6) **Quantity Production and Stockpile** (AEC brings production to full scale; DoD continues appraisal of weapons performance)

**Department of Defense Directives**

DoD Directive 3150.1, entitled, "Joint Nuclear Weapons Development Studies and Engineering Projects," expands on these phases with the following directions:<sup>28</sup>

E) 1. Concept Definition Studies (Phase 1):

- a. Any DoD Component (with the cooperation of other DoD Components and the DoE, as desired) or the DoE may conduct a Phase 1 study to define a weapon concept and to help the DoD Component concerned and the USDR&E decide whether to proceed with a joint Phase 2 study.
- b. If the Phase 1 study foresees the modification of an existing nuclear weapon *or the development of a new nuclear weapon*, the DoD Component concerned shall ask the DoE to examine the practicability of at least that portion of the concept.

An updated version of DODD 3150.1, entitled "Joint DoD-DOE Nuclear Weapon Life-Cycle Activities," requires that DoD procedures for nuclear weapons life-cycle activities shall "Require full coordination of all nuclear weapons development, production, sustainment, and retirement projects with the DoD Components and the DOE."<sup>29</sup>

DoD Directive 2060.1, entitled, "Implementation of, and Compliance with, Arms Control Agreements," mandates that "All DoD activities shall be fully compliant with arms control agreements of the U.S. Government." The Directive requires the Under Secretary of Defense for Acquisition, Technology, and Logistics to: "As necessary, establish a DoD compliance review group (CRG) for each arms control agreement...to monitor compliance of all DoD activities and to coordinate DoD guidance on issues arising from questions of compliance"; "Certify, as necessary, that specific planned activities are in compliance with arms control agreements"; "Monitor all DoD activities for compliance with arms control agreements and, as necessary, conduct or direct reviews to determine if there are issues that should be brought before a CRG to ensure compliance"; and "Provide direction and oversight for the conduct of research and development to support DoD arms control agreement implementation and compliance."<sup>30</sup>

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<sup>28</sup> DODD 3150.1 Joint Nuclear Weapons Development Studies and Engineering Projects:  
<[http://www.fas.org/nuke/guide/usa/doctrine/dod/dodd-3150\\_1.htm](http://www.fas.org/nuke/guide/usa/doctrine/dod/dodd-3150_1.htm)>

<sup>29</sup> Joint DoD-DOE Nuclear Weapon Life-Cycle Activities, March 8, 2004:  
<[http://www.dtic.mil/whs/directives/corres/pdf/d31501\\_082602/d31501p.pdf](http://www.dtic.mil/whs/directives/corres/pdf/d31501_082602/d31501p.pdf)>

<sup>30</sup> DoD Directive 2060.1: <[http://www.dtic.mil/whs/directives/corres/pdf/d20601\\_010901/d20601p.pdf](http://www.dtic.mil/whs/directives/corres/pdf/d20601_010901/d20601p.pdf)>

## **Congressional Oversight of Nuclear Weapons**

According to a presentation by Stephen I. Schwartz at the 2005 Carnegie Endowment International Non-Proliferation Conference, jurisdiction over the U.S. nuclear weapons program is distributed among no fewer than 30 congressional committees and subcommittees.<sup>31</sup> Primary jurisdiction resides in the following committees:

- House Armed Services Committees
  - Subcommittee on Strategic Forces
- House Appropriations Committee
  - Subcommittee on Defense
  - Subcommittee on Energy and Water Development
  - Subcommittee on Science, the Departments of State, Justice, and Commerce
- House Energy and Commerce Committee
  - Subcommittee on Energy and Air Quality
- House Budget Committee
- House Science Committee
  - Subcommittee on Energy
  
- Senate Armed Services Committees
  - Subcommittee on Strategic Forces
- Senate Appropriations Committee
  - Subcommittee on Defense
  - Subcommittee on Energy and Water Development
  - Commerce, Justice, Science, and Related Agencies
- Senate Energy and Natural Resources Committee
  - Subcommittee on Energy
- Senate Budget Committee
- Senate Environment and Public Works Committee
  - Subcommittee on Clean Air, Climate Change, and Nuclear Safety

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## **ALTERNATIVE NUCLEAR WEAPONS DEVELOPMENT**

Among the pillars of the international nuclear nonproliferation regime – chiefly the NPT and the CTBT – considerable definitional ambiguity exists concerning the nuclear weapons and nuclear weapons-related activities proscribed under the treaties. While scholars have debated the applicability of these agreements to advanced research into non-traditional nuclear weapons – including low-yield nuclear weapons, nuclear spin

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<sup>31</sup> Schwartz, Stephen I. "A Brief History of Congressional Oversight of Nuclear Weapons," Carnegie Endowment International Non-Proliferation Conference November 8, 2005:  
<<http://www.carnegieendowment.org/static/npp/2005conference/presentations/Schwartz.pdf>>

isomers, pure-fusion weapons, antimatter/positron weapons and low energy nuclear reactions – substantial government funding has been invested in these fields.

### **Low-yield Nuclear Weapons Research and Development**

The 1993 Spratt-Furse law, included as part of the FY 1994 National Defense Authorization Act, states that, “It shall be the policy of the United States not to conduct research and development which could lead to the production by the United States of a new low-yield nuclear weapon,” defined as having a yield of less than five kilotons.<sup>32</sup> This prohibition was repealed by the FY 2004 National Defense Authorization Act with the stipulation that “The Secretary of Energy may not commence the engineering development phase, or any subsequent phase, of a low-yield nuclear weapon unless specifically authorized by Congress.”<sup>33</sup> However, even before the repeal of Spratt-Furse, scholars had questioned whether the ambiguity of the law’s definition of permissible research left open the possibility that research on low-yield nuclear weapons could occur as long as it stopped short of being used to “develop” an actual weapon.<sup>34</sup>

As part of the Advanced Concepts Initiative of the 2001 Nuclear Posture Review, the Pentagon advocated “improved earth penetrating weapons (EPWs) to counter the increased use by potential adversaries of hardened and deeply buried facilities.”<sup>35</sup> This concept would be embodied in the controversial RNEP program. The FY 2004 Energy and Water Appropriations Act includes the following provision concerning “Advanced Concepts”: “The conferees provide \$7,500,000 for the [RNEP study, instead of \$5,000,000 as proposed by the House and \$15,000,000 as proposed by the Senate. The conferees remind the Administration that none of the funds provided may be used for activities at the engineering development phases, phase 3 or 6.3, or beyond, in support of advanced nuclear weapons concepts, including the [RNEP].”<sup>36</sup>

Following a contentious debate in Congress, the FY 2005 Consolidated Appropriations Act discontinued funding for RNEP. For FY 2006, while funding for RNEP was requested (to be divided between the NNSA and DoD), Congress again chose not to appropriate funds. NNSA requested no funds for RNEP for FY2007.<sup>37</sup>

### **Pure Fusion Weapons**

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<sup>32</sup> P.L. 103-160: <<http://www.cns.miis.edu/pubs/week/030528.htm>>

<sup>33</sup> P.L. 108-136: <<http://www.dod.mil/dodgc/olc/docs/2004NDAA.pdf>>

<sup>34</sup> Wang, Justine. “Congressional Bills Passed Support Bush Agenda for New Nuclear Weapons,” Nuclear Age Peace Foundation. December 9, 2003: <[http://www.wagingpeace.org/articles/2003/12/09\\_\\_wang\\_congressional-bills.htm](http://www.wagingpeace.org/articles/2003/12/09__wang_congressional-bills.htm)>

<sup>35</sup> Ferguson, Charles D. “Mini-Nuclear Weapons and the U.S. Nuclear Posture Review,” Center for Nonproliferation Studies: <<http://www.cns.miis.edu/pubs/week/020408.htm>>

<sup>36</sup> FY 2004 Energy and Water Appropriations Act: <<http://thomas.loc.gov/cgi-bin/cpquery/T?&report=hr357&dbname=108&>>

<sup>37</sup> Medalia, Jonathan. “‘Bunker Busters’: Robust Nuclear Earth Penetrator Issues, FY2005-FY2007.” Congressional Research Service Report, February 21, 2006: <<http://www.fas.org/spp/crs/nuke/RL32347.pdf>>

During the 1975 NPT Review Conference, U.S. representatives issued a statement regarding laser fusion research holding that "Such contained explosions are not 'other nuclear explosive devices' in the sense of the NPT and research in this area is allowed under Article IV."<sup>38</sup> When the Clinton Administration submitted the CTBT to the Senate for ratification in 1997, its accompanying statement maintained that Inertial Confinement Fusion was allowed under the treaty.<sup>39</sup>

In a 1998 paper entitled "The Question of Pure Fusion Explosions Under the CTBT," Suzanne L. Jones and Frank N. von Hippel suggested that, "Fusion research involving implosions of deuterium-tritium targets driven by laser or particle beams appears to be widely accepted as not prohibited under the [CTBT]."<sup>40</sup> Their paper offers a technical basis for establishing a ban on the development of pure fusion weapons. The same year, scholars of the Institute for Energy and Environmental Research (IEER) published a paper, "Dangerous Nuclear Quest," arguing that laboratory fusion explosions are indeed illegal under the CTBT and that the U.S. National Ignition Facility thus violated international law. While acknowledging the difficulty in defining a "nuclear explosion" under the CTBT, the authors propose a variety of limitations – including limiting the energy releases from fusion reactions to less than the input into the fuel pellet, limiting neutron production and banning the use of tritium in systems driven by high explosives – to forestall the creation of fusion weapons without hampering innocuous fusion research.<sup>41</sup> DOE rejected the conclusion of the report, arguing that fusion experiments did not constitute "nuclear explosions" as defined by the CTBT, and further insisted that the U.S. has no program to develop fusion weapons.

Despite criticism about U.S. noncompliance with the CTBT, research involving "magnetized target fusion" has been conducted in collaboration between the Los Alamos National Laboratory and the All-Russian Institute of Experimental Physics at Sarov. Additionally, the Sandia National Laboratory has conducted research involving the use of x-rays to implode small fusion targets.<sup>42</sup>

### **Nuclear Isomer Weapons**

In 2003, DARPA invested \$7 million in research to study the feasibility of artificially triggering the isomer hafnium-178, with additional funding planned in subsequent years.<sup>43</sup> Research on hafnium-178 is underway at the Air Force Research Laboratory at

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<sup>38</sup> Makhijani, Arjun and Zerriffi, Hisham. "Dangerous Thermonuclear Quest" – Chapter 5: Nuclear Disarmament and Non-Proliferation Issues, Institute for Energy and Environmental Research, July 1998. <<http://www.ieer.org/reports/fusion/chap5.html>>

<sup>39</sup> Ibid.

<sup>40</sup> Jones, von Hippel, "The Question of Pure Fusion Explosions Under the CTBT," *Science & Global Security*, 1998, Volume 7, pp. 129-150:

<[http://www.princeton.edu/~globsec/publications/pdf/7\\_2Jones.pdf](http://www.princeton.edu/~globsec/publications/pdf/7_2Jones.pdf)>

<sup>41</sup> Makhijani, Arjun and Zerriffi, Hisham. "Dangerous Thermonuclear Quest" – Chapter 5: Nuclear Disarmament and Non-Proliferation Issues, Institute for Energy and Environmental Research, July 1998. <<http://www.ieer.org/reports/fusion/chap5.html>>

<sup>42</sup> Jones, von Hippel.

<sup>43</sup> Weinberger, Sharon. "Scary Things Come in Small Packages," *The Washington Post*, March 28, 2004: <<http://www.washingtonpost.com/ac2/wp-dyn/A22099-2004Mar24?language=printer>>

Kirtland, New Mexico. The Defense Technologies Information Center listed hafnium weapons in its "Military Critical Technologies List," declaring that such weapons possess "the potential to revolutionize all aspects of warfare" – evidence that research into nuclear isomers is oriented toward potential weaponization.<sup>44</sup> In 2002, DoD created the Hafnium Isomer Production Panel (HIPP) to explore the mass production of hafnium for military purposes.<sup>45</sup>

According to a May 2004 piece in *Physics Today*, "Because isomer weapons would not involve transmutation of nuclear species, they don't come under the rubric of existing nonproliferation treaties."<sup>46</sup> However, though comparatively little fallout would result from a nuclear-isomer explosion versus a traditional fission explosion, the dispersion of un-detonated isomer material as radioactive particles may, in theory at least, contradict a key tenet of the LTBT concerning the "contamination of man's environment by radioactive substances."

Despite a \$4 million budget request from the Bush Administration, the House and Senate Armed Services Committees slashed funding for Stimulated Isomer Energy Release (SIER) in the DARPA budget and recommended the transfer of responsibility for such research from DoD to the NNSA. According to the HASC report language accompanying the FY 2005 defense authorization bill, "Given the significant policy issues associated with any eventual use of an isomer weapon and given the inability of distinguished scientists to replicate the reported successful triggering experiment of 1998, the committee believes that [DoD] should not be engaged in this research. The proper agency to investigate the feasibility of this technology is the [NNSA] and its national laboratory complex."<sup>47</sup>

### Antimatter / Positron Weapons

According to the *San Francisco Chronicle*, the U.S. Air Force has channeled \$3.7 million to the firm Positronics Research LLC for positron research, though this funding may support national security priorities far beyond the development of advanced munitions.<sup>48</sup> In a March 24, 2004, presentation to a NASA Institute for Advanced Concepts (NIAC) conference, Kenneth Edwards of the Munitions Directorate at Eglin Air Force Base stressed the potential applications of positrons to propel continuous-flight surveillance aircraft and space vehicles with relatively little emphasis on weapons development.<sup>49</sup>

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<sup>44</sup> Schwarzschild, Bertram. "Conflicting Results on a Long-Lived Nuclear Isomer of Hafnium Have Wider Implications." *Physics Today*, May 2004: <<http://www.physicstoday.org/vol-57/iss-5/p21.html>>

<sup>45</sup> Davidson, Keay. "Superbomb ignites science dispute." *The San Francisco Chronicle*, September 28, 2003; <<http://sfgate.com/cgi-bin/article.cgi?file=/c/a/2003/09/28/MN23720.DTL&type=printable>>

<sup>46</sup> Schwarzschild.

<sup>47</sup> American Institute of Physics, "Armed Services Committees Refuse to Authorize SIER Weapon Research," FYI Number 76: June 4, 2004: <<http://www.aip.org/fyi/2004/076.html>>

<sup>48</sup> Davidson, Keay. "Air Force pursuing antimatter weapons," *The San Francisco Chronicle*, October 4, 2004: <<http://www.sfgate.com/cgi-bin/article.cgi?file=/c/a/2004/10/04/MNGM393GPK1.DTL>>

<sup>49</sup> Edwards, Ken. "Propulsion and Power with Positrons." NIAC Fellows Meeting, 24 March, 2004: <[http://www.niac.usra.edu/files/library/meetings/fellows/mar04/Edwards\\_Kenneth.pdf](http://www.niac.usra.edu/files/library/meetings/fellows/mar04/Edwards_Kenneth.pdf)>

However, Edwards did note that “no nuclear residue” would result from positron explosions, theoretically avoiding the environmental “contamination” that early test ban treaty proponents sought to prevent.

### **Low Energy Nuclear Reactions (Cold Fusion)**

In a February 2002 report entitled, “Thermal and Nuclear Aspects of the Pd/D<sub>2</sub>O System,” Dr. Frank E. Gordon, Head of the Navigation and Applied Sciences Department of the Space and Naval Warfare Systems Center, San Diego, wrote: “We do not know if Cold Fusion will be the answer to future energy needs, but we do know the existence of Cold Fusion phenomenon through repeated observations by scientists throughout the world. It is time that this phenomenon be investigated so that we can reap whatever benefits accrue from additional scientific understanding. It is time for government funding organizations to invest in this research.”<sup>50</sup> From July 31-August 3, 2006, the National Defense Industrial Association and the Office of Naval Research co-hosted a Naval Science & Technology Partnership Conference in Washington, D.C., where Dr. Gordon hosted an “LENR Breakout Session” to discuss Space and Naval Warfare Systems Command research developments in low energy nuclear reaction research.

Coverage of Dr. Gordon’s remarks in the *New Energy Times* contained the following claim about U.S. government support for Cold Fusion research: “Although the U.S. Department of Energy has yet to fund studies in the area, the Defense Advanced Research Projects Agency, long known for boldness in funding research, has been funding small LENR projects quietly for many years and recently has taken a renewed interest in the subject.”<sup>51</sup>

The Internet abounds with additional reports of undetermined veracity suggesting that DARPA support for LENR, while discreet, is ongoing. However, little evidence suggests that the focus of this research is oriented toward the development of weapons.

### **Miscellaneous – Foreign Investment in Alternative Nuclear Weapons**

A 2006 report by the Center for the Study of Weapons of Mass Destruction at National Defense University notes that, “Moscow seems intent on maintaining a full range of weapon types and exploring new ones, including precision low-yield, pure fusion, ‘clean’ penetrators’, and nuclear isomer weapons.”<sup>52</sup>

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<sup>50</sup> Technical Report 1862. “Thermal and Nuclear Aspects of the Pd/D<sub>2</sub>O System – Volume 1: A Decade of Research at Navy Laboratories.” <<http://www.spawar.navy.mil/sti/publications/pubs/tr/1862/tr1862-vol1.pdf>>

<sup>51</sup> Krivit, Steven and Daviss, Bennett. “Extraordinary Evidence.” *New Energy Times*, November 10, 2006. <<http://lenr-canr.org/acrobat/KrivitSextraordin.pdf>>

<sup>52</sup> WMD Center 2006 Annual Symposium: “The Future Nuclear Landscape: New Realities, New Responses.”: <<http://www.ndu.edu/WMDCenter/docUploaded/Symposium%202006%20-%20Key%20Themes.pdf>>



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Defense Intelligence Agency

EXHIBIT "C"

## ***Defense Analysis Report***

DIA-08-0911-003

13 November 2009

### **Technology Forecast: Worldwide Research on Low-Energy Nuclear Reactions Increasing and Gaining Acceptance**

***Scientists worldwide have been quietly investigating low-energy nuclear reactions (LENR) for the past 20 years. Researchers in this controversial field are now claiming paradigm-shifting results, including generation of large amounts of excess heat, nuclear activity and transmutation of elements.<sup>1,2,3</sup> Although no current theory exists to explain all the reported phenomena, some scientists now believe quantum-level nuclear reactions may be occurring. DIA assesses with high confidence that if LENR can produce nuclear-origin energy at room temperatures, this disruptive technology could revolutionize energy production and storage, since nuclear reactions release millions of times more energy per unit mass than do any known chemical fuel.<sup>4,5</sup>***

#### **Background**

In 1989, Martin Fleischmann and Stanley Pons announced that their electrochemical experiments had produced excess energy under standard temperature and pressure conditions.<sup>6</sup> Because they could not explain this physical phenomenon based on known chemical reactions, they suggested the excess heat could be nuclear in origin. However, their experiments did not show the radiation or radioactivity expected from a nuclear reaction. Many researchers attempted to replicate the results and failed. As a result, the physics community disparaged their work as lacking credibility, and the press mistakenly dubbed it "cold fusion." Related research also suffered from the negative publicity of cold fusion for the past 20 years, but many scientists believed something important was occurring and continued their research with little or no visibility. For years, scientists were intrigued by the possibility of producing large amounts of clean energy through LENR, and now this research has begun to be accepted in the scientific community as reproducible and legitimate.

#### **Source Summary Statement**

This assessment is based on analysis of a wide body of intelligence reporting, most of which is open source information including scientific briefings, peer-reviewed technical journals, international scientific conference proceedings, interviews with scientific experts and technical media. While there is little classified data on this topic due to the S&T nature of the information and the lack of collection, DIA judges that these open sources generally provide the most reliable intelligence available on this topic. The information in this report has been corroborated and reviewed by U.S. technology experts who are familiar with the data and the international scientists involved in this work.

Although much skepticism remains, LENR programs are receiving increased support worldwide, including state sponsorship and funding from major corporations.<sup>7,8,9,10</sup> DIA assesses that Japan and Italy are leaders in the field, although Russia, China, Israel, and India<sup>11</sup> are devoting significant resources to this work in the hope of finding a new clean

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energy source. Scientists worldwide have been reporting anomalous excess heat production, as well as evidence of nuclear particles<sup>12, 13, 14</sup> and transmutation.<sup>15, 16, 17</sup>

- Y. Iwamura<sup>18</sup> at Japan's Mitsubishi Heavy Industries first detected transmutation of elements when permeating deuterium through palladium metal in 2002.
- Researchers led by Y. Arata at Osaka University in Japan<sup>19</sup> and a team led by V. Violante at ENEA in Italy (the Italian National Agency for New Technologies, Energy, and the Environment—the equivalent to the U.S. Department of Energy)<sup>20</sup> also made transmutation claims.
- Additional indications of transmutation have been reported in China, Russia, France, Ukraine, and the United States.<sup>21, 22</sup>
- Researchers in Japan, Italy, Israel, and the United States have all reported detecting evidence of nuclear particle emissions.<sup>23, 24</sup>
- Chinese researchers described LENR experiments in 1991 that generated so much heat that they caused an explosion that was not believed to be chemical in origin.<sup>25</sup>
- Japanese, French, and U.S. scientists also have reported rapid, high-energy LENR releases leading to laboratory explosions, according to scientific journal articles from 1992 to 2009.<sup>26, 27</sup>
- Israeli scientists reported in 2008 that they have applied pulsating electrical currents to their LENR experiments to increase the excess energy production.<sup>28</sup>
- As of January 2008, India was reportedly considering restarting its LENR program after 14 years of dormancy.<sup>29</sup>

U.S. LENR researchers also have reported results that support the phenomena of anomalous heat, nuclear particle production, and transmutation.<sup>30, 31, 32</sup>

- At the March 2009 American Chemical Society annual meeting, researchers at U.S. Navy SPAWAR Pacific reported excess energy,<sup>33</sup> nuclear particles,<sup>34</sup> and transmutation,<sup>35, 36</sup> stating that these effects were probably the result of nuclear reactions.<sup>37</sup>
- A research team at the U.S. company SRI International has been studying the electrochemistry and kinetics of LENR since the early 1990's, reporting excess heat and helium production.<sup>38</sup>

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- In May 2002, researchers at JET Thermal in Massachusetts reported excess heat and optimal operating points for LENR manifolds.<sup>39</sup>
- Researchers at the China Lake Naval Air Warfare Center in California first reported anomalous power correlated with Helium-4 production in 1996.<sup>40</sup>

Although no one theory currently exists to explain all the observed LENR phenomena, some scientists now believe these nuclear reactions may be small-scale deuterium fusion occurring in a palladium metal lattice.<sup>41, 42, 43</sup> Some others still believe the heat evolution can be explained by non-nuclear means. Another possibility is that LENR may involve an intricate combination of fusion and fission triggered by unique chemical and physical configurations on a nanoscale level.<sup>44, 45</sup> **This body of research has produced evidence that nuclear reactions may be occurring under conditions not previously believed possible.** Recent results suggest these anomalous LENR phenomena can be triggered by various energetic stimuli (electric and magnetic fields, acoustic waves, infrared, lasers)<sup>46, 47</sup> and may have a variety of operational modes.

### Nuclear Fusion

Nuclear fusion as currently understood occurs only in the core of stars, in nuclear weapons, in high temperature plasmas, or in inertially confined high-energy collisions. Scientists for years have attempted to harness nuclear fusion through high-temperature plasma techniques but have been unable to produce more energy output than supplied. Fusion was once thought to be the answer to the world's future clean energy needs, but after 60 years of research still has yet to live up to this promise. "Hot" fusion researchers do not believe fusion can occur at near-room temperatures based on the Coulomb barrier that repels like nuclear charges and have dismissed much of the "cold fusion" research conducted since 1989. As a result, such research has received limited funding and support over the past 20 years.

### Potential Applications of LENR: The Technology Surprise Factor

LENR's potential as a future clean energy source is still unknown. However, recent results indicating nuclear activity and transmutation are intriguing and pose the following questions:

- If the excess heat from these experiments could be captured and intensified, could LENR be used as a power source for engines, batteries, or other equipment?
- If nuclear particles could be generated and transmute elements, could LENR be used to mitigate hazardous waste or to neutralize weapons of mass destruction?<sup>48</sup>
- If the various modes of energy production could be identified and optimized, could LENR be used to create designer materials or critical resources that are in short supply or serve as a tailored, "dial-a-mode" power source?

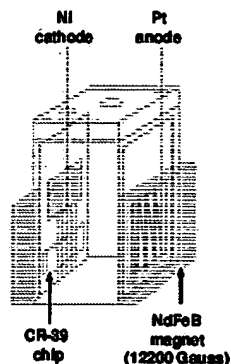
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- If rapid, explosive energy output can occur in one or several modes, could LENR serve as a new high-energy-density explosive?

International LENR research was highlighted in April 2009 on a U.S. television program focused on the 20th anniversary of the Fleischman and Pons announcement.<sup>49</sup> Many U.S. researchers are collaborating with foreign scientists, but each team has proprietary aspects of their experiments that are not shared. Because some peer-reviewed journals are reluctant to review or publish LENR data due to past controversies, most results are presented at international conferences, and foreign scientists have access to much of the U.S. data. In addition, U.S. experts have been invited to brief on LENR to nuclear institutes in India,<sup>50</sup> Belgium,<sup>51</sup> and South Korea,<sup>52</sup> and a reciprocal visit by South Koreans to SPAWAR Pacific to initiate collaboration is planned. This relatively free flow of information increases the likelihood of a technology breakthrough—as well as the potential for technology surprise—by an international team, especially those from countries that are devoting more resources to this research than is the United States, and are supported with major corporate funding (Mitsubishi, Toyota, and Honda in Japan; Pirelli in Italy).<sup>53</sup>

### The Experiments

Most LENR experiments involve electrodes immersed in solutions of metal salts such as lithium chloride or lithium sulfate, with heavy water substituted for natural water. Electric current is sent through the experimental apparatus, in most instances producing excess heat. This effect occurs over long periods (several hundreds of hours), and many early experimenters achieved negative results because they were unaware of this incubation period. Israeli researchers used pulsating electric fields to increase heat production. The application of magnetic fields has been shown to stimulate increased heat and power. Usually one of the electrodes is palladium, because it has a high ability to adsorb (hold on the surface) and absorb deuterium atoms in its metal matrix. Deuterium is an isotope of hydrogen that undergoes fusion in nuclear weapons at high temperatures and pressures; it also undergoes fusion and is one of the basic building blocks of the heavier elements formed in stars. The Navy SPAWAR experiments used a unique technique to place the palladium atoms in the heavy-water solution and to codeposit palladium and deuterium, which rapidly increases the deuterium "loading" necessary for the LENR phenomena to occur.



A Notional LENR Electrochemical Cell (Left) and a French LENR Apparatus After an Unexplained Explosion (Right)<sup>54</sup>

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### Who's Hot in Cold Fusion?

The countries with the most advanced LENR programs are Japan, Italy, and Israel. In addition, Russia, France, China, South Korea, and India are spending significant resources on LENR research. The following are among the most notable efforts:

- In Japan, Iwamura at Mitsubishi has been studying transmutation of elements in LENR experiments and multilayer palladium (Pd) complexes. His team includes the Japanese Synchrotron Radiation Research Institute and SPring-8 at Riken. Kitamura and other researchers at Kobe University are investigating Pd nanopowders and Helium-4 ash. Arata at Mitsubishi Heavy Industries has worked on catalysts containing nanopalladium. Yamaguchi at Kobe noted transmutation using multilayered Pd samples. Mizuno at Hokkaido is studying transmutations and heat generation. A team led by Hioki at Toyota is investigating deuterium gas permeation through Pd as well as transmutations. Toriyabe at Tohoku University is developing charged-particle detectors for LENR. Kasagi is looking at electron and ionic screening in LENR effects.
- Vittorio Violante, a leader in the field of Pd metallurgy and the role of surface effects in LENR, heads a team at ENEA, Frascati Rome; (the Italian equivalent to the U.S. Department of Energy) performing LENR experiments. A team led by Francesco Celani at INFN that includes STMicroelectronics and Pirelli labs is studying deuterium migration in nanocoated Pd for fast-loading and anomalous heat effects. The Italian Physical and Chemical Societies are supporting LENR research in Italy.
- Srinivasan in India noted that India is restarting its LENR program; the Bhabha Atomic Research Centre had several groups working on LENR from 1989 to the early 1990s. Sinha at IISc in Bangalore is studying models for fusion in metal deuterides. Lakshmanan at Saveetha College is exploring fusion in sodium metal solutions.
- Andrei Lipson and other researchers at the Russian Academy of Sciences and scientists in Tomsk are studying the emission of charged particles during the use of electron beams to excite palladium/deuterium (Pd/D) and titanium/deuterium (Ti/D) targets. Karabut and others at LUCH also are conducting LENR experiments. A Dubna team led by Gareev is studying nuclear fusion during cavitation and molecular transitions. LUCH's Savvatimova, Dash, Muromtsev, and Artamonov also are conducting LENR experiments. Adamenko and Vysotskii of Kiev are looking for magnetic monopoles in LENR experiments. Kurchatov-based scientist Goryachev is investigating LENR for alternative energy sources and for mitigating radioactive waste.
- Xing Z. Li at Tshinghua University claims 20 institutions in China are investigating LENR with governmental support. Tian's team at Cahnchun University of Science and Technology is investigating laser triggering in Pd/D systems. Zhang and other researchers at the Chinese Academy of Sciences have studied Pd-D kinetics in LENR since 1991.
- Israeli scientists at Energetics in Omer have shown that variations in energy output can be increased using variable frequency or pulsed "superwaves" to stimulate LENR effects.
- The French Atomic Energy Agency had an official LENR program from 1997 to 1999. EDF also had one for several years. Currently, Jean-Paul Biberian from the Universite Marseille and Jacques Dufour at CNAM are working on LENR in France.
- Jan Marwan of Dr. Marwan Chemie in Berlin, Germany, is studying the nanostructure of palladium hydride systems. Huke and others from the Technische Universitat Berlin are working with Czerski in Poland and Ruprecht in Canada on electron screening mechanisms for deuteron fusion.

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### Outlook and Implications

If nuclear reactions in LENR experiments are real and controllable, DIA assesses that whoever produces the first commercialized LENR power source could revolutionize energy production and storage for the future. The potential applications of this phenomenon, if commercialized, are unlimited. The anomalous LENR effects seen in these metal lattices containing deuterium may also have as-yet undetermined nanotechnology implications. LENR could serve as a power source for batteries that could last for decades, providing power for electricity, sensors, military operations, and other applications in remote areas, including space. LENR could also have medical applications for disease treatment, pacemakers, or other equipment. Because nuclear fusion releases **10 million times more energy per unit mass** than does liquid transportation fuel, the military potential of such high-energy-density power sources is enormous. And since the U.S. military is the largest user of liquid fuel for transportation, LENR power sources could produce the greatest transformation of the battlefield for U.S. forces since the transition from horsepower to gasoline power.

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<sup>1</sup> Bockris, John, "The History of the Discovery of Transmutation at Texas A&M University," paper presented at the 10<sup>th</sup> International Conference on Cold Fusion (ICCF), Cambridge, MA, 2003.

<sup>2</sup> 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.

<sup>3</sup> The number of protons in the nucleus of an atom determines the identity of the chemical element. Nuclear transmutation occurs when the number of protons in the nucleus is changed by adding or removing protons or converting them to other nuclear particles. Thus transmutation changes one chemical element into another through a nuclear process.

<sup>4</sup> Benedict, M., T. Pigford, and H. Levi, "Nuclear Chemical Engineering," McGraw Hill Series in Nuclear Engineering, 1981.

<sup>5</sup> Hecker, S., "Plutonium, A Historical Overview," *Challenges in Plutonium Science*, Vol. 1, Los Alamos, National Laboratory. No. 26, 2000.

<sup>6</sup> Journal of Electroanalytical Chemistry, Vol. 261, 263, 287, pp 187, 301, 293.

<sup>7</sup> DeChiaro, Louis, "Recent Progress in Low Energy Nuclear Reactions," briefing prepared by NAVSEA, Dahlgren, for DDR&E, 28 August, 2009.

<sup>8</sup> Iwamura, Yashiro, et al., "Transmutation Reactions Induced by D<sub>2</sub> Gas Permeation Through Pd Complexes (Pd/CaO/Pd)," 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.

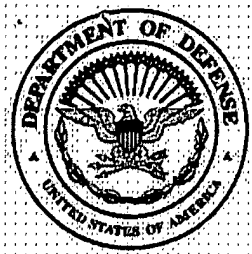
<sup>9</sup> Hioki, Tatsumi, et al., "Influence of Deuterium Gas Permeation on Surface Elemental Change of Ion-Implanted Pd," 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.

<sup>10</sup> Celani, Francesco, et al., "Deuteron Electromigration in Thin Pd Wires Coated with Nano-Particles: Evidence for Ultra-Fast Deuterium Loading and Anomalous, Large Thermal Effects," 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.

- <sup>11</sup> "Exciting New Science; Potential Clean Energy," Abstracts, 14<sup>th</sup> International Conference on Condensed Matter Nuclear Science and International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>12</sup> Mosier-Boss, et al. "Triple Tracks in CR-39 as the Result of Pd/D Co-deposition: Evidence of Energetic Neutrons," *Naturwissenschaften*, 96, 2009, 135-142.
- <sup>13</sup> Mosier-Boss, et al., Navy SPAWAR briefing, American Chemical Society annual meeting, March 2009.
- <sup>14</sup> "Exciting New Science; Potential Clean Energy," Abstracts, 14<sup>th</sup> International Conference on Condensed Matter Nuclear Science and International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>15</sup> Transmutations only occur when nuclear particles interact and are exchanged to produce different elements.
- <sup>16</sup> Iwamura, Yashiro, et al., "Transmutation Reactions Induced by D<sub>2</sub> Gas Permeation Through Pd Complexes (Pd/CaO/Pd) 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>17</sup> Yamaguchi, Tatsuya, et al., "Investigation of Nuclear Transmutation Using Multilayered CaO/X/Pd Samples Under Deuterium Permeation," 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>18</sup> Iwamura, Yashiro, et al., "Elemental Analysis of Pd Complexes: Effects of D<sub>2</sub> Gas Permeation," *Japan Journal of Applied Physics*, Vol 41, 2002, pp. 4642-4650.
- <sup>19</sup> Arata, Y., "Anomalous Effects in Charging of Pd Powders with High Density Hydrogen Isotopes," *Physics Letters A*, 373, 2009, pp 3109-3112.
- <sup>20</sup> Violante, V. et al., "On the Correlation of PdD Alloy Material Properties with the Occurrence of Excess Power," briefing presented at 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>21</sup> Prelas, M.A., et al., "A review of Transmutation and Clustering in Low Energy Nuclear Reactions," briefing presented at Vice Chancellor for Research Seminar on LENR, University of Missouri, May 2009.
- <sup>22</sup> Briefings presented at Navy SPAWAR San Diego, LENR meeting, 4-5 August, 2009.
- <sup>23</sup> Mosier-Boss, et al. "Triple Tracks in CR-39 as the Result of Pd/D Co-deposition: Evidence of Energetic Neutrons," *Naturwissenschaften*, 96, 2009, 135-142.
- <sup>24</sup> Mizuno, Tadahiko, "Neutron Emission Induced by Nuclear Reaction in Condensed Matter," briefing presented at Vice Chancellor for Research Seminar on LENR, University of Missouri, May 2009.
- <sup>25</sup> Zhang, et al., "On the Explosion in a Deuterium/Palladium Electrolytic System," Third International conference on Cold Fusion, 1992, Nagoya, Japan.
- <sup>26</sup> Biberian, Jean-Paul, "Unexplained Explosion During an Electrolysis Experiment in an Open Cell Mass flow Calorimeter," *Journal of Condensed Matter, Nuclear Science*, 2 (2009) pp. 1-6.
- <sup>27</sup> Zhang, et al., "On the Explosion in a Deuterium/Palladium electrolytic System," Third International conference on Cold Fusion, 1992, Nagoya, Japan.
- <sup>28</sup> Lesin, et al., "Ultrasonically-Excited Electrolysis Experiments at Energetic Technologies," *Energetics Technologies*, Omer, Israel, briefing presented at 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008
- <sup>29</sup> Jayaraman, K.S., "Cold Fusion is Hot Again," *Nature India*, 2008. Published online 17 Jan 2008. <http://www.lenr-canr.org/acrobat/JayaramanKcoldfusion.pdf>
- <sup>30</sup> Mosier-Boss, et al., multiple briefings presented at Navy SPAWAR Pacific, August 4-5, 2009.
- <sup>31</sup> McKubre, Michael, "Studies of the Fleischmann-Pons Effect at SRI International," briefing presented at Vice Chancellor for Research Seminar on LENR, University of Missouri, May 2009.
- <sup>32</sup> Spzak, Stan, et al., "Evidence of Nuclear Reactions in the Pd Lattice," *Naturwissenschaften*, 92, 2005, 394-397.
- <sup>33</sup> Spzak, Stan, et al., "Thermal Behavior of Polarized Pd/D Electrodes Prepared by Co-Deposition," *Thermochimica Acta*, 410, 2004, 101-107.
- <sup>34</sup> Mosier-Boss, et al., "Triple Tracks in CR-39 as the Result of Pd/D Co-deposition: Evidence of Energetic Neutrons," *Naturwissenschaften*, 96, 2009, 135-142.
- <sup>35</sup> Spzak, Stan, et al., "Evidence of Nuclear Reactions in the Pd Lattice," *Naturwissenschaften*, 92, 2005, 394-397.
- <sup>36</sup> The identity of a chemical element is determined by the number of protons in its atomic nucleus. Transmutation occurs when one chemical element is changed into another one. This normally occurs during radioactive decay, but can occur from any number of nuclear processes that add or subtract protons from the atomic nucleus.
- <sup>37</sup> Mosier-Boss, et al., Navy SPAWAR briefing, American Chemical Society annual meeting, March 2009.
- <sup>38</sup> McKubre, Michael, "Studies of the Fleischmann-Pons Effect at SRI International," briefing presented at Vice Chancellor for Research Seminar: Excess Heat and Particle Tracks from Deuterium-Loaded Palladium, University of Missouri, 29 May 2009.

## UNCLASSIFIED

- <sup>39</sup> Swartz, Mitchell, et al., "The Impact of Heavy Water (D<sub>2</sub>O) on Nickel-Light Water Cold Fusion Systems," Proceedings of the 9<sup>th</sup> International Conference on Cold Fusion, ICCF-9, Condensed Matter Nuclear Science, May 19-24, 2002, Beijing, China, Tsinghua University Press, 2003, pp 335-342.
- <sup>40</sup> Miles, Melvin, et al., "Anomalous Effects in Deuterated Systems," Final Report, NAWCWPNS TP 8302, Naval Air Warfare Center Weapons Division, 1996.
- <sup>41</sup> Hagelstein, Peter and Irfan Chaudhary, "Modeling Excess Heat in the Fleischmann-Pons Experiment," briefing presented at Vice Chancellor for Research Seminar on LENR, University of Missouri, May 2009.
- <sup>42</sup> Olenik, V.P. and Yu. D. Arepjev, "Physical Mechanism of Nuclear Reactions at Low Energies," National Technical University of Ukraine, Kiev Polytechnic Institute
- <sup>43</sup> Srivastava, Y.N., O. Panella, A. Widom, "Instability of the Perturbation Theoretical Chromodynamic Vacuum," LANL web site, arXiv:0811.3293v1 20 Nov 2008.
- <sup>44</sup> Hagelstein, Peter, MIT, Briefing, Navy SPAWAR Pacific, August 2009.,
- <sup>45</sup> McDaniel, Patrick, "Electrochemically Induced Nuclear Reactions," briefing, presented at Navy SPAWAR Pacific, August 2009.
- <sup>46</sup> Sinha, K.P. and A.Meulenberg, "Laser Stimulation of Low-Energy Nuclear Reactions in Deuterated Palladium," Current Science, Vol.91, No.7, 10 October, 2006, pp. 907-912
- <sup>47</sup> Lesin, et al., "Ultrasonically-Excited Electrolysis Experiments at Energetic Technologies," Energetics Technologies, Omer, Israel, briefing presented at 14<sup>th</sup> International Conference on Cold Fusion (ICCF), Washington, DC, 10-15 August 2008.
- <sup>48</sup> Tsvetkov., S.A., "Possibility of Using Cold Fusion for Nuclear Waste Products Transmutation," 10<sup>th</sup> International Conference on Cold Fusion, Cambridge, MA, 2003. from LENR-CANR.org website.
- <sup>49</sup> <http://www.cbsnews.com/stories/2009/04/17/60minutes/main4952167.shtml?tag=contentMain:contentBody>
- <sup>50</sup> Personal correspondence, Dr. Michael McKubre, SRI International, October, 2009.
- <sup>51</sup> Forsley, L., "Lattice Assisted Nuclear Reactions: Overview of an Unexpected Phenomena," First Colloquium on Nano-Nuclear Science l'Universite catholique de Louvain, Belgium, May 4-5, 2009.
- <sup>52</sup> Personal correspondence, Mr. Lawrence Forsley, JWK International, October, 2009.
- <sup>53</sup> In Japan, the three major automakers are supporting LENR research. In Italy, Pirelli Labs is one of many corporate and governmental sponsors of LENR research.
- <sup>54</sup> Biberian, Jean-Paul, "Unexplained Explosion During an Electrolysis Experiment in an Open Cell Mass flow Calorimeter," *Journal of Condensed Matter, Nuclear Science*, 2 (2009) pp. 1-6.



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# Advanced Systems and Concepts Office **FINAL REPORT**

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